JPRS-UCC-87-006

27 APRIL 1987

USSR Report

CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

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[Article by Engineer V. A. Legonkov]

[Abstract] A study is presented of the status and developmental trends in the area of operational testing during the manufacture of functional computer units based on printed circuit boards, integrated microcircuits and electronic elements. The subject of the study is the methods and equipment used for nondestructive testing of the quality of functional units after the manufacture of printed circuits and assembly of functional units. A classification of means used for testing of printed circuits and functional units is presented. It is noted that optical testing equipment is universal and does not require physical contact with the devices being tested, making it quite promising for testing of electronic equipment. A description is presented of algorithms used to process 2-dimensional images. Technical characteristics are presented of some optical test equipment (all of which is manufactured in the U.S. Although optical equipment alone cannot satisfy the demands of the electronics industry for test equipment, in combination with traditional electronic test equipment, optical equipment can find broad utilization. References 75: 69 Russian, 6 Western.

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TRENDS AND PROSPECTS FOR DESIGN OF ADAPTIVE MECHANISMS FOR ACTIVE SYSTEM FUNCTIONING

Moscow IZMERENIYA KONTROL AVTOMATIZATSIYA in Russian, No 4, 1985, pp 53-60

[Article by Doctor of Technical Sciences V. N. Burkov and Candidate of Technical Sciences V. V. Tsyganov]

[Abstract] Adaptive management of hierarchical organizational systems such as social-economic systems requires that the human factor be considered, resulting from the fact that the elements of the system have their own goals in addition to the system-wide goals. In the 70's and early 80's, studies in this area concentrated on identification of deterministic structures by analysis of response in such systems, whereas at present methods are under development for estimation of the status of active systems with indeterminate structure, utilizing methods of learning. Learning functioning mechanisms are capable of improving their functioning as time passes, and must be applied when the center must operate under conditions of uncertainty. The ocnstruction of learning functioning mechanisms is based on the utilization of learning processes using probability iterative algorithms which allow deficiencies in a priori data to be supplemented by processing current information, achieving improved functional qualities. This article studies learning as applied to pattern recognition to illustrate this process. Development trends and the prospects for introduction of adaptive mechanisms are analyzed. It is noted that neither the rewards nor penalties applied to individuals in such a system should be too great, since either case discourages elements from utilizing all internal resources. The design of progressive adaptive functioning mechanisms must be directed toward the creation of systems of methods, algorithms and analysis program with pattern recognition, classification and prediction of states of production-economic elements with a degree of approximation. The system must represent a component part of a combined mechanism of functioning of the organizational system, must be capable of learning and self improvement as conditions change, and must support man-machine dialog methods of operation. A new language called "APPROXIMATION" has been developed which satisfies these requirements and is based on the practice of functioning of a complex mechanism.
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INFORMATION SYSTEM ARCHITECTURE

Moscow NAUCHNO-TEKHNICHESKAYA INFORMATSIYA, SERIYA 2. INFORMATSIONYYE PROTSESSY I SISTEMY in Russian, No 8, Aug 86 (manuscript received 6 Feb 86) pp 14-20

[Article by M. Sh. Tsalenko and D. S. Chyeryeshkin]

[Abstract] A discussion is presented of the architecture of automated information systems, and an approach is developed to the creation of the principles of design of such systems. The concept of the "architecture" of a system is defined as the man-machine complexes creating the material organized medium necessary for maintenance and development of the material and spiritual life of the society. In recent years, information system architecture has significantly changed, shifting from traditional rigid architecture to architectures providing increasing flexibility and adaptability in the implementation of various information technologies. The principle of modularity has allowed abstraction from the internal architecture to the architecture presented to a user. Major trends in the development of information system architecture include increasing complication of the internal structure of practically all components, the predominance of the modular principle of arrangement of the information system, increasing significance of such components as information organization, organization of support and access, the trend toward replacement of hierarchical architecture with single-level or matrix structures, and increases in the "intelligence" of systems by increasing the degree of logical perception and logical thinking of the information system itself and of its architectural arrangement, with machine implementation of logical relationships in the performance of various servicing tasks. Soon information system designers will base design decisions on user needs rather than available system capabilities. Figures 5, references 21: 10 Russian, 11 Western.

6508/12955
CSO: 1863/67

AUTOMATED CONTROL SYSTEMS: MODELS, PRACTICAL MANAGEMENT AND A WORKABLE ECONOMY (FOLLOWING UP A ROUNDTABLE DISCUSSION)

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 22 No 5, Sep-Oct 86, pp. 903-915

[Article by V. I. Danilov-Danilyan]

[Text] The materials of a roundtable discussion of the problems and prospects of development of automated control systems (ASU) [1-3] testify to the need to return once more to the conceptual matters of the introduction of information science, computer technology and economic-mathematical modeling in the system of planned direction of the national economy and management of its components. The general acknowledgement of the fact that the actual results are far from justifying the expectations previously and still associated with computerization of the economy is the most important argument for stating that the practical needs for theoretical development projects often remain unsatisfied, regardless of whether or not individual purchasers, design engineers or operators of the ASU are aware of these needs. And the participants of the roundtable discussion were unanimous in admitting that no generally accepted, convincing, unified concept of computerized management yet exists.

Could such concept be unnecessary or impossible? It cannot be ruled out, but the many speakers pointing out the need for the concept and the negative consequences of its rudimentary state indicate that there are serious flaws in the methodological foundation of ASU development. These are especially evident at the stage of preparation of the technical request for design, i.e., the formulation of the tasks to be handled by the ASU and the determination of its functions in the management system.

Incidentally, we have committed a definite stylistic blunder: just what are the functions of an ASU, i.e., an automated control system, in a control [management] system? However, this blunder is no accident: it reflects the contradiction between the original understanding of the term ASU, which was given to it 20 years ago and continues to be used in certain theoretical investigations to the present day, and the actual content which it has taken on in practice. How has this contradiction come about, and what methodological conclusions follow from the mere fact of its existence? What advances in management are possible by computerization and which of its characteristics will probably be left untouched by the change in techniques, organizational forms and so forth? What are the ways of using economic-mathematical models in daily management practices and what results might be achieved?

The present article discusses only certain aspects of these subjects, leaving untouched other no less important problems of computerization of management--the methods of designing the systems, the choice of a hardware complex, the organization of the software, and so forth.

WHAT IS AN AUTOMATED CONTROL SYSTEM?

This question was posed by O. I. Aven at a roundtable discussion, ten years previous to the discussion in [1-3] on the initiative of the editors of the journal "Economics and Mathematical Methods" and the Science Council of the USSR Academy of Sciences on the subject "Optimal Planning and Management of the National Economy" [4-5]. "The first Soviet work on the use of the computer in management goes back to 1959" [4, p. 1200]; the decade and a half since that time has been distinguished by a variety of practical achievements, clarification of problem situations, and intense theoretical research. The results of this period have been summed up in the discussion [4-5]. It would appear that quite a lot of material has been accumulated for a generalization. Even so, O. I. Aven points out with full justification: "Practice reveals that no single and clearcut understanding of an ASU has yet been formed" [4, p. 1205]. The truth of these words is supported by analysis of those attempts to answer this question in the discussion of 1974. There was no unanimity--or even conviction--in the answers. The efforts to find a solution, taking general system theory as a point of departure, proved clearly untenable; another approach used the concept of a "macrosystem," interpreting this more in a cybernetic or systems engineering manner, but even this concept was so vague that its use in definitions could only give rise to new problems. The accent on the fact that what was being defined was not so much something in existence, as something that should exist, was distinctly expressed in the viewpoint apparently shared by the majority of specialists in the early 1970s: "The ASU is...a system of economic management, growing out of the existing system on the basis of equipping it with new scientific methods, modern control techniques and technology" [5, p. 182]. There were no objections to this approach at the 1974 roundtable, although, naturally, its interpretation could not be unequivocal. Let us attempt to educe a number of corollaries from this definition, first expressing the extreme viewpoint.

The main assertion in the cited definition is that an ASU arises in place of a previous, nonautomated management system, growing out of it by an evolution or, as certain other authors feel, replacing and abolishing it by a "revolution." Management itself should become qualitatively different, significantly and fundamentally more effective. We may note that this applies to all elements and levels of the economic structure. The project engineer of an ASU, it is believed, should in fact become the design engineer of a control system, determining the goals and facilities of the overall management process, its principles and methods, content and form. The computer technology and other equipment are viewed as the necessary condition for all qualitative transformations, their initiating start and constituent element.

It might appear that more consequences have been inferred from the original formulations than were warranted. Yet an attentive study of the literature pertaining to the first period of ASU development projects reveals that we have not exaggerated in presenting the customary views of the theoreticians of economic cybernetics and management computerization in the late 1960s and early 1970s. Exaggeration--in assessment of the possibility of automating certain aspects of management and of the process itself as an integrated whole--was characteristic of the ASU developers during that time. But whereas the differences of opinion were practically unnoticeable then, it appears they are now in evidence and are concentrating on the question: either to adhere to the given definition, as previously, or to reject it. Actually, the problem is whether to identify the control [management] system of a particular object in the modern understanding of control [management], on the one hand, with an ASU, on the other, or to assume that the "ASU" is only a portion of such system. The conflicting opinions of the participants of the 1984 discussion are presented in [1, p. 545].

At risk of stating the obvious, let us keep in mind that management is a creative process, although requiring every possible means of support, which specializes the diversity of auxiliary functions (naturally, this applies to management of so-called organizational-economic systems, which differ from technical systems by the fact that people are both the subjects and the objects of the control in them.) It is possible to formalize and automate (to some extent) such auxiliary functions and the types of managerial activity supporting them, but not the creative essence of the process. One often has occasion to witness how this obvious truth, after simple "particularizing" manipulations, is well nigh converted into a statement as to the basic unknowability of socioeconomic phenomena. But, in the first place, formalization is not the sole and necessary result of knowledge, nor even its ideal. The objections to this usually quote Kant, giving not an exact citation, but a garbled rewording of his following assertion: "In any particular study of nature it is possible to find only as much science, properly speaking, as there is mathematics in it" [6, p. 58]. Of importance here is not only what Kant writes about natural science (he again calls attention to this circumstance in a later place), but also the meaning attributed to the term mathematics: "Pure knowing by the mind, from concepts alone, is known as pure philosophy or metaphysics; but that which bases its knowledge only on the construction of concepts, representing an object in a priori contemplation, is known as mathematics" [op. cit., pp. 57-58]. It is hardly necessary here to explain the relationship of these assertions to Kantian apriorism and so forth, for even without this it is perfectly clear that his dictum in no way warrants judgments of the type "socioeconomic processes are known only insofar as their description is mathematicized."

Secondly, we must not forget that all organizational-economic systems evolve, sometimes under the influence of their reflection in the human mind, while neither genuine evolution nor the dialectics of the process of knowing can in principle be formalized. It is perfectly obvious that "the deepening of our knowledge and the accumulation of experience are continually enlarging the domain of phenomena more or less admitting of formalization. This does not mean that the domain of processes and phenomena as yet nonformalized is diminishing. As socialist society evolves, ever newer aspects of its functioning appear, so that we should be talking of a certain shifting of the domain of nonformalized phenomena, and not its disappearance" [7, pp. 219-220].

Therefore, in order for management of organizational-economic systems to be effective and far-reaching, it should proceed from an adequate evaluation of the scientific apparatus used, the completeness of the "knowledge bank" (as it is called in the modern theory of artificial intelligence), including the means of formalization, quantitative analysis, information reliability, and so forth. Overestimating such appraisal is a mistake which inevitably entails other mistakes--in the managerial decisions themselves.

The recent period has demonstrated, probably to all, that the main reserve of raising the quality of management is not automation. Moreover, automation in itself offers either little or nothing, but may even inflict damage, if the substantive characteristics of the management, by their nature not related to automation (indeed by their nature, and not by the forms of their appearance in modern conditions) are not up to par. Such characteristics are, foremost, dedication in raising the quality of management and in objective social evaluation of its results, and pursuit of the interests of the state, not the bureaucracy or seniority (we may mention, by the way, that while there are serious conflicts between the former and the latter interests, it is usually by no means easy to understand what are state interests when solving a particular economic problem; moreover, it is widely believed that a kind of "complete" reconciliation of interests is possible, and what is more, on a purely economic basis, which in our opinion is an illusion.) The participants of the 1984 discussion emphasized that the chief factor in raising the quality of management is an improvement in the economic relations, development of social structures, economic thinking, social consciousness in general, and a culture of production and management (cf., in particular [1, p. 549]).

But if management is a process which is creative in its substance and cannot be fully "objectivized", if the main factor in raising its quality is not automation or the adoption of information computing technology (if only because effective use of the latter requires very definite conditions, the creation of which also becomes a priority), then it is time to abandon the thesis that "the ASU is...a system of economic management." Bearing in mind the practical development projects, such abandonment (in our view) has already become a reality and constitutes the primary change in ideas concerning ASU over the past 10 years. It is necessary to admit the obvious: the ASU is a control system which makes use of modern information computing technology in carrying out its functions.

It is necessary, however, to go further and acknowledge that, in the foreseeable future, all control [management] systems and all their users will employ such technology, be it only a personal computer. It will then have to be admitted that the "A" in the abbreviation ASU is superfluous, for all control systems will become partly automated, while total automation is impossible in organizational-economic, as opposed to technological systems.

Consequently, the task of ASU is to develop informational, mathematical, computing, software, and if necessary hardware resources enabling implementation of the individual control functions (Footnote *) (Such approach is perfectly consistent with the experience in the West. As pointed out in [8, p. 911], "The American specialists employ two terms similar to our ASU: the first is a system of management information..., the second is a decision support system," the latter "does not evolve decisions, but helps the manager to correctly do so" [op. cit., p. 912]). "The sector ASU (OASU) do not control the sectors. They simply perform the job of supplying information to the sector management apparatus" [3, p. 929]. We may add to this, first, that the quoted remark of G. V. Oboladze may apply with equal force not only to OASU, but also to the ASU of organizational-economic systems of all other levels; second, this state of affairs, characteristic of the present day, will also persist in the future; third, qualitatively new technology, more sophisticated models and the like will not alter the situation in principle (in the aspect under discussion), but merely raise the level of servicing, improve the effectiveness of results and enlarge the range of application.

R. Ya. Levita is surely correct in proposing a renaming of ASU, for example, to ASOU - automated management servicing systems [1, p. 545]. It is not, however, a purely terminological dispute. In the present case, the incorrect term, not fitting the reality and used in despite of common sense, contributes to strengthening undesirable stereotypical thinking, spreading confusion and error.

Prior to the formulation of the now rejected definition, in 1974 it was remarked that: "The ASU is not a computer center with its staff" [5, p. 182]. Of course, a computer center, or even an information and computing center, with its personnel, is not a control [management] system (SU), whatever attributes are imparted to this term (e.g., "automated" - A), if only because it (the computer center) does not exercise all control [management] functions, much less integrate them. However, in the first place, the practical understanding of ASU in the majority of instances is in fact a computer center with its staff and the group of development engineers, if this is part of the organization but does not belong to the regular staff of the computer center, and there is some justification for this view, which is much closer to the actual state of affairs than the theoretical ideas of 1974, if also somewhat narrow. Secondly, a computer center with its staff is apparently still regarded by many as the necessary attribute of computerized management, at least insofar as a special group of employees is needed for the use of information computing technology by a specific management system. But because of the very fact that situations have already become quite common where an organization uses such technology in its management with neither special servicing personnel, nor programmers, nor operators on its staff, and taking into account the rapid progress in enhancing the reliability of computers, the lower volume of repairs, the specialization of their maintenance and programming, the development of collective-use computer systems, the processes of integration of computers into networks, and finally the immense spread of the personal computer, there is no doubt that the employees "specifically assigned" to information computing technology will become increasingly less essential to the regular staff of both the management apparatus itself and the organization being managed, except, of course, in those instances where a full-fledged "information plant" is required because of the specific nature of the enterprise.

Such a view may perhaps arouse the objections of certain investigators who identify the task of the ASU with development of overall management systems, and who therefore approach its justification from a different angle.

The management of the national economy is an evolving system, and the impulses for its evolution arise both from inside and outside. Of course, in such context, it is necessary to understand management in the broad meaning of the term, allotting an adequate place to the social management channels. Moreover, we have in mind here not only structures of national economic level, but also the lower-lying formations, provided they are organizational-economic (and not purely technological) structures. Hence it follows that the development of a management system--not in its entirety, not for individual elements--cannot be regarded as being wholly predetermined by a certain outside standardizing and organizing principle, the exponent of which is the ASU design engineer, for example. In other words, the upgrading of management systems, as any other process of development, cannot be treated as formulated exclusively "from the top down", in the present instance, from science, ignoring the internal motivations, the operationally understood needs and the readiness to mobilize possibilities. Such ignoring, by the way, undoubtedly occurred in the 1960s and 1970s and was one of the major reasons for a series of failures in ASU design, adoption and operation. During this period, especially at the medium and lower levels of management, the ASU often became something of a gift of science and the national economy as a whole to those organizations for which it was designed. But any gift, if it does not correspond to fully understood urgent needs of the recipient and, what is more, if it requires considerable exertion on the part of the latter in order to be used, will not be assimilated in whole or in part, but instead rejected altogether.

Consequently, a management system designed "from the outside", standardized and introduced "from the top down", can only be the rare exception; clearly, such system is only advisable on occasion at new enterprises. Normally, however, there should be a process of finding out the needs for information science and automation by the currently existing systems and a development of projects to meet these needs on a modern methodological and hardware level, with very active involvement of the customers themselves. As the information computing hardware, software, access facilities and the like are modernized, the need for individual design at relatively low levels of the management structure will be reduced, at the same time expanding in the direction of more complex tasks with updating of the arsenal of methods for handling them. This trend is already quite distinct today, as pointed out in [1-3], but unfortunately is not always considered in future practical design projects.

THREE APPROACHES TO THE DESIGN OF ASU

At the outset of ASU development projects, there were lengthy disputes concerning two approaches to the design of these systems: "from a snapshot" and "from a model."

The first approach consisted in the fact that, after careful on-site study of the existing management system for which the ASU was being designed, those junctions and channels would be identified where the generation, registration, transmission and processing of data could be transferred at least in part to the hardware, and without changing anything essential in these processes or the structure of interactions, the management system would be furnished information and computing facilities appropriately adapted in hardware, software and other respects. There is an obvious internal contradiction in this approach: the nature of such "snapshot" is unclear--for an exhaustive description of the reality is not possible, and a selection of the important features is unavoidable. Yet this is no longer a snapshot, but a model (we shall not go into the clearly unnecessary discussion of the fact that a snapshot is also a model and so forth--the meaning of the above seems perfectly evident.) Thus, an objective snapshot of an existing management system, precluding the subject, the goal, the distinction of important and unimportant induced by these, and so forth, is simply impracticable, and yet this was taken as the beginning and most critical stage of ASU development.

The second approach regarded the analysis of structure and functions of existing management systems as only a decidedly tentative stage, which along with a more meaningful and actually essential investigation of the object of the management itself is required to construct a model of the type of management system needed, given the preconditions brought to light by the investigation, and thereby (as a minimum) placing limits on the future development of the object. In accordance with the second approach, such model is in fact the foundation of the ASU. In our opinion, this concept also lacks a firm methodological base--not even its most dedicated advocates have reached the necessary clarity of understanding the meaning invested in the term model in this context, or what a model of management should represent. The primary reason in the present case is the lack of an operational formulation of the goal of the modeling: efforts to achieve such result in a vicious circle (the goal of the modeling is to design and introduce an ASU, but the ASU itself is defined in terms of the model of management of the object.)

While the "snapshot" approach has been justifiably characterized as unilaterally empirical, the "model" approach is, in our view, the utmost expression of the concept identifying an ASU with an economic management system. It is sometimes said that practice has chosen a certain middle ground, although this is hardly possible: the snapshot and the model are interpreted in the approaches under discussion such that there is no middle between them. They are situated not only in different planes, but also in different spaces: the first in an empirical-descriptive, the second in a normative-prescriptive. Eclectic attempts, when the "model" approach is applied not to a management system as a whole, but to certain of its parts, contradict the most fundamental premise: to model management as a whole.

In the best development projects, the practice has gone, not a middle way, but a fundamentally different way: on the basis of need, which clearly emerges from many of the remarks at the roundtable discussion in 1984. Such procedure, naturally, presupposes an active influencing of the processes of understanding the need for computerization of management by the workers of the management system themselves and "converting" these needs into the forms where they can be structurally satisfied with the given level of technical development, and formulation of such needs in the coming term. Without activity in all these areas, such approach would degenerate into a narrowly empirical and primitively utilitarian. As in all other fundamental aspects of computerization of economics, the most important factor here is determined by the general process of upgrading the management of the national economy and reorganization of economic thought. The needs for computerization by local elements, given their outlook and intensity, will only correspond to the national goals when such needs are governed by interest in raising the quality of management and comprehensive adoption of the achievements of scientific-technical progress.

In the modern setting, the need for computerization by the management apparatus of many economic elements is limited to automated information systems (AIS). At times, such outlook comes from the desire to avoid "unnecessary" bother, as long as the economic mechanism and the situation of the economy do not compel an active search, a creative approach in the upgrading of management at the enterprise or association. However, in many cases the AIS is the only presently advisable equipment of information-computer technology for organizational-economic management. In this case, the AIS can and should form the underpinning for continuing work in computerization and accustoming the managers to the use of modern decision support equipment. To remove the notorious "psychological barrier", a gradual adoption of computerization (according to the level of complexity of the tasks entrusted to the information computing systems, or the difficulty of using the services they provide) is important, and in the majority of cases the AIS are perfectly appropriate as the first stage. It is vital, however, that they be built from state-of-the-art components, in order to provide a high quality of services; otherwise, they will not play the part of an initiating stimulus in the process of accustoming the management workers to the use of advanced decision making methods. The 1984 discussion also expressed a point of view whereby heightened attention to AIS is regarded as a negative factor, and the corresponding outlook viewed as "technocratic" [1, p. 545]. It would appear that, in the present case, a differentiated approach is essential. But while limiting a project to the framework of AIS may prove an unwarranted simplification, it is by no means an expression of technocratic tendencies: on the contrary, such tendencies (i.e., the attempt to solve by technical means a problem in which the key role is played by manifestly nontechnical aspects) are characteristic of the view of ASU as an"integral system of control of an economic object."

If in the process of introducing information computer technology in management we proceed from the recognized need for automation of individual management functions, it may turn out that integration is not achieved in this way, and without this no significant impact is obtained from the use of computers. Here is yet another reason for accusing the "need-based" approach of excessive empiricism, because of its orientation toward an already existing management structure, as well as unwarranted mechanisticity, due to the breakdown of management into elements, as occasioned by this structure. Let us examine these objections.

First, we may note that computerization of management is, in certain cases, a significant, but never the major factor in reorganization or formulation of a management structure of an economic object. Moreover, its function in this respect is diminishing by the development of adaptive software capabilities and the appearance of problem-oriented langauges, "intelligent" information retrieval systems, knowledge banks, and other facilities classified as achievements of "artificial intelligence." The higher the level of the software, and the more adaptive its components, the more invariant it becomes to changes in the organizational structure of management. These changes are primarily directed at a different apportionment of managerial tasks among the structural subdivisions and their workers (we shall not even mention other aspects, still more distant from computerization), but this has little effect on the requirements for the ASOU, of course, provided it corresponds to the present state of the art, and not 15 years into the future. The creation of new tasks or the transition to different methods of solving the old ones is a different matter. Here, increased demands on the ASOU are highly likely, but there is no rigid correlation with advances in the organizational structure: there may be no change at all, a rearrangement may follow at a certain delay, or (conversely) a reorganization may be undertaken for the purpose of initiating a changeover of the administration to new assignments. In our view, the desire to necessarily connect changes in computerization of management with changes in its organizational structure comes from the same perception of an ASU as an economic management system.

Let us now turn to the problem of integration in connection with the "need-based" approach. First of all, let us ascertain what it is that is supposed to be integrated. Clearly, not the management functions within a certain formalized system, for the problem of such integration in the situations now concerning us is fundamentally unsolvable. After all, it is a question of synthesizing management decisions in an organizational-economic system, while the problem of such synthesis is nonformalizable, according to the nature of its content, and inevitably exceeds the bounds of any given formalized system. Therefore, the accusation of mechanisticity of the "need-based" approach on account of the decomposition of management into functions or elements does not hold up: such decomposition, whatever the alternative, is inevitable in creating systems of information-computing management support.

Integration should concern the hardware and software supporting the individual management functions in a unified complex, if, of course, the conditions for such integration have come together and its implementation is feasible. The corresponding complex should be designed (or synthesized from already-existing separate elements) as a unified whole, on the basis of the discovered requirements for automation of management tasks and functions. The means of satisfying such individual requirements need not be narrowly specialized, of course. Genuine integration is always characterized by a lack of one-to-one correspondence between the needs and the resources.

However, there is far from unanimity in the understanding of integration in this domain. Previously, we were talking about integration of management functions in the context of a single object, primarily, an enterprise. In addition, there is the question of vertical integration between management systems at different structural levels and horizontal integration between the management agencies of objects on the same level. Many participants of the 1984 discussion took up these aspects (cf. [1, pp. 550-551, 2,3]. As it appears, the first priority in such analysis should be devoted to methodological problems of management--the relationship between theory and practice, model and reality, model and problem which it has been designed to solve. We have already emphasized the point that the creative element cannot be divorced from management of organizational-economic systems. Too much belittling of its value, too much emphasis on the capabilities of formalization and modeling, may contribute to the formation of imaginary problems, the attempts to solve which divert energy and resources with no significant theoretical or practical return. One such problem, having in our view no adequate justification for its formulation in reality, is global integration of ASU, ASPR, and the like. Of course, this applies to the approach to this problem as if it were practical and urgent, and not the theoretical elaboration of the respective aspects, which might bring interesting indirect results and, possibly someday, also direct practical ones.

"The prevailing approach is characterized by autonomy of ASU. We have gone so far in making individual systems autonomous, that their integration now is very complicated and expensive" [2, p. 751]. But what does it mean to integrate systems? It is only possible to construct proposals, for no comprehensive analysis of the problem can be glimpsed behind this slogan (listing the aspects of integration [op. cit., p. 750] does not introduce clarity.) From the standpoint of conventional systems analysis, a certain degree of autonomy of elements is not only not repudiated, but actually affirmed, when it is a question of integrated socioeconomic systems. But which kinds of systems is it proposed to integrate in the given quotation? Apparently, ASU. Let us then see how the idea of global integration accords with the various interpretations of ASU. We shall only dwell on the two main ones.

If "an ASU is a system of economic management," then all such systems of whatever level and of all objects will be integrable elements. "It is essential to design the ASPR as a single entity, in order for all the planning subsystems to be contained in it as integrated parts.... An integrated system should be organized, from the enterprise to the USSR Gosplan" [2, p. 751]. Let us recall that this proposes to overcome the "autonomy of ASU." But isn't the management system of an enterprise just as autonomous as the enterprise itself? Aren't we placing the cart before the horse? Doesn't this interpretation of ASU, and the principle of their global integration, lead us to declare that computerization is a constructive principle for upgrading the management system of the national economy? No, however important the orientation toward extensive use of information computer techniques in economic management, to assign it the central role can only be done within a purely technocratic approach.

But if we have in mind systems of automated servicing of management, the product of which is not management, but partial automation of its individual functions, not decisions, but the information for making them, and so forth, then the problem of integration loses its fundamental economic tenor and becomes a technical plan: certain components of the ASOU are to be integrated when this is technologically and economically advisable, i.e., brings about lower expenses, raises the quality of services offered, enlarges their composition, and so on. Of paramount importance in this respect is, of course, the upgrading of the system of plan supervision of the national economy, the economic mechanism in whole and in parts, while computerization and integration of computer systems being developed or already present (which are not the same thing as computerized systems, i.e., those using information computing technology) is only one aspect of this process.

The idea of global integration had been enunciated previously, but in different words, e.g., "by the end of 1976, to modify or create from scratch procedural materials on the design of ASU of all levels, consistently adhering to the premise that the ASU is a method of systematic upgrading of management on the basis of the theory of optimal functioning of a socialist economy" [5, p. 180]. At first glance, this is a matter of developing unified principles for design of ASU, and not their integration into a unified system without autonomy of the elements. But, in the first place, economic and organizational principles that are unified for such diverse objects and assignments can only be extremely general and abstract. And the principal (in our view) approach to the formation of ASU--to create them "as needed", primarily taking into account the specifics of the object of control and its specific tasks--compels an attitude of caution to the very idea of any sort of general normative principles outside the sphere of technology and information science. Secondly, it is evident to those acquainted with the theoretical context of the quoted position, defined by the development of the SOFE in the 1960s and early 1970s, that the mentioned principles are regarded here as the methodological base for practical integration in the precise and narrow meaning of the term.

The appeals to develop and implement a general plan of measures for an automation of management, resulting in a unified integrated ASU for the various levels and objects (and such appeals would have had to be sounded not only in 1974, but 10 years previously), are today, as 10 or 20 years ago, an attempt (in our opinion) to forestall events, which might even result in failure to use the actually existing possibilities at our disposal and obtain the results that are so necessary in practice and fully feasible. While in 1964-1965 such ideas were a potent stimulus to theoretical thought and an important stage in understanding the range of problems of the incipient scientific trend, they can no longer play this role today and manifestly do not conform to the specifics and range of problems of the current moment, or the realistic trends of future development. We may mention that formulations of the problems of management of a socialist economy, corresponding to the above-given quotations, appear to us fundamentally incorrect (cf. [9]). But efforts to curtail the "autonomization of individual systems" [2, p. 751] cannot fail to be correlated with a curtailment of the independent standing of the enterprises and associations, which is in conflict with the program of expanding such independence, and cannot fail to bring about a hampering of the development prospects of the local economic units. A strengthening of the centralized principle of direction of the economy must be sought in other areas, but this subject goes far beyond the bounds of the present article.

But what indeed should be integrated, if the primary form of introduction of information computing technology in management is considered to be the creation of automated systems to support its functions? This question was in fact answered by many of the participants of the 1984 discussion, and it only remains for us to repeat the main points for a consistent presentation. First, the integration of hardware, information systems, computer algorithms, and organizational software at an enterprise is advisable within broad limits, having in mind not only the servicing of the functions of organizational-economic management themselves, but also the SAPR, as well as the components of the production technology--the GPS, GAP, and the like. Second, the transmission of data between management systems should be universally automated; naturally, this is the most primitive form of computer integration "between entities", but it may produce extremely tangible results. Third, as the necessary economic conditions ripen and economic integration within the framework of the associations, for example, becomes a reality, it is necessary to carry out an integration of the servicing of the management function of the resulting entity, without hurry, and taking into account the preparedness of the staff and a multiplicity of other factors (and not in the reverse manner, attempting to use computerization as a stimulus--in the original meaning of the word--for economic integration).

USE OF MODELS IN ASOU

The principal form of operation of modern information computing technology is the interactive mode. There are no special theoretical problems when this concerns the use of information reference or retrieval systems, nor (let us say) the solving of problems of a statistical nature. But such problems result from a development of normative type models, primarily optimization models, within an ASOU [automated system for organizational control]. Let us discuss certain methodological aspects of optimization calculations in interactive mode.

Interactive mode can be carried out on two levels: in the most simple case, interactive software helps the user pick out an appropriate computational algorithm, formulate an appropriate access to it, determine and specify his preferences regarding output of the solution or presentation of the results; more sophisticated facilities offer the possibility of an active dialogue with the model itself, its informational and structural modifications, and so on. We are interested in the second case, and it is in this sense that we shall use the word interaction.

Recourse to interactive mode in the solving of optimization problems is always caused by indeterminacy, regardless of the specific form in which it is manifested: inaccuracy of the original information, unclear preferences, the desire to include features of the control object not directly represented in the model, poor structurization of the problem, and so on. An expert, solving a planning or management problem in interactive mode, does not actually work with a single software problem, but a set of related formal problems, generated by an identical original structure or scheme. There are two possible alternatives: either the expert during the dialogue settles on one of the numerical realizations of this scheme, performing a kind of search in the particular set of such realizations (such set is usually not itself specified definitively--on occasion it is valid to consider it as fuzzy, and the search as poorly regularized, even though equipped with a potent tool--the optimization algorithm and utility programs executing a jump from one realization to another, prompting the directions of such jumps, and so on), or the expert is not satisfied with any of the plans optimizing the examined realizations of the original scheme, instead putting together a certain composition of fragments thereof, perhaps supplementing this with "outside" elements at his discretion. Such composition is based on relatively stable components of particular optimal solutions (i.e., present in the majority of them.) This alternative is especially useful in cases where the problem being solved is discrete in its economic subject matter, or contains at least individual elements of a discrete nature (the layout of production, the assignment of suppliers to consumers, the formation of a file of orders, etc.).

The concept of optimization of an economy places fundamental importance on evaluations of an optimal plan as the means of guiding its implementation, and the indexes that should enter into the composition of parameters of the economic mechanism. Such role is assigned to the elements of the solution of a dual problem in the case of all levels of optimization. The effective range of the corresponding estimates is simply limited to the same bounds as the optimal plan of the primal problem. For example, if the current plan of an enterprise is being optimized, the dual solution (as is assumed) should be used in "tuning" the internal cost accounting at the given enterprise. These ideas are developed in the theory of optimal functioning, given the hypothesis that the activity of the object of control is adequately described by the optimization model. The realization of such hypothesis appears to us doubtful; nevertheless, without going into the epistemological and methodological problems, but taking it as granted, let us determine to what extent its inferences can be extended to the case when the planning with an optimization model is done in interactive mode between an expert and the computer.

The solution obtained with the help of a model in interaction mode, i.e., a dialogue in the above defined sense, does not possess, nor in theory can it possess those properties, relative to the original problem, which are customary to the mathematicians developing the optimization methods or the economists using them in theoretical constructions. Let us revise the previous description of the formulation and solving of an optimization model in interactive mode. For simplicity and definiteness, we shall assume that the model is formalized as a linear programming problem. However, as pointed out above, the expert does not possess a "ready-made" problem, but only information concerning a set of possible realizations of its numerical content and structural modifications. We shall introduce yet another simplification, namely, we assume that this set, i.e., the totality of linear programming problems corresponding to the initial problem, is distinct. Neither of these assumptions reduces the generality of the conclusions, for since they are negative, these conclusions which are valid for the particular case will naturally apply to the general as well.

Thus, the original optimization scheme can be represented as a set M of triple points (A,b,c), where A is a matrix, b and c are vectors "congruent" in dimensionality with it, i.e., they form a linear programming problem:

$$\max_{x \in Q} cx, \quad Q=\{x:x\geqslant 0,\ Ax\leqslant b\}.$$

This problem we shall denote by (A,b,c), the set of its optimal solutions by $X^*(A,b,c)$, and the set of optimal solutions of the problem that is the dual to (A,b,c) by $P^*(A,b,c)$ (no special symbol shall be used for this.)

In the first of the above two characterized alternatives of active interaction, the expert is supposed to select such problem $(\bar{A},\bar{b},\bar{c})$ from M, the optimal solution of which (one of such solutions) he will take as the end result, the required plan for the original problem as a whole. In this case, there is no formal criterion of selection from M and, consequently, no methodological basis for designating any given $\bar{x} \in X^*(\bar{A},\bar{b},\bar{c})$ an optimal plan (in our opinion, it is more accurate in the present case to employ the term OPTIMIZED.) Whereas the vector $\bar{x} \in X^*(\bar{A},\bar{b},\bar{c})$ naturally possesses all the attributes of an optimal solution with respect to its "proper" problem $(\bar{A},\bar{b},\bar{c})$, it is generally neither optimal, nor allowable with respect to $(A',b',c') \in M$, not coinciding with $(\bar{A},\bar{b},\bar{c})$. There is no more basis for considering $\bar{p} \in P^*(\bar{A},\bar{b},\bar{c})$ as optimal estimates, correlative with the initial problem and the set M representing it: less so, because the expert chooses $(\bar{A},\bar{b},\bar{c})$ for the sake of a certain $\bar{x} \in X^*(\bar{A},\bar{b},\bar{c})$, but not a $\bar{p} \in P^*(\bar{A},\bar{b},\bar{c})$. If specially asked which vector of estimates he would prefer, e.g., in "tuning" the parameters of internal cost accounting at an enterprise, it is highly likely that the choice would fall to $\tilde{p} \in P^*(\tilde{A},\tilde{b},\tilde{c})$, given $(\tilde{A},\tilde{b},\tilde{c}) \neq (\bar{A},\bar{b},\bar{c})$.

Such choice may appear paradoxical (it would seem that $\bar{p}$ is indeed congruent with $\bar{x}$, and once $\bar{x}$ is chosen, the preferableness of $\bar{p}$ is already predetermined), but only if we forget about the well-known impossibility of "total adequacy" between a model and a real object.

The expert, however, will always be aware of factors not fitting into the formal scheme (even one of utmost extent, given by M), and he might have reason to expect that the pair $(\bar{x},\tilde{p})$ is better suited to these factors and to the purpose of the decision being made, than $(\bar{x},\bar{p})$ or $(\tilde{x},\tilde{p})$.

Of course, discrepancies between the vectors of the plans and the estimates which are optimal for different elements of M may be more or less important. Therefore, no general answer (strictly speaking) can be given for the problems discussed, and even the problems themselves (as well as the problem of optimization in interactive mode) are not entirely rigorous. In each specific case, one should study the variation of the elements in the set M, to say nothing of the multiplicity of the aggregations

$$\bigcup_{(A,b,c)\in M} X^{\bullet}(A,b,c) \quad \text{and} \quad \bigcup_{(A,b,c)\in M} P^{\bullet}(A,b,c),$$

which is by no means easy (let us observe that the dimensionalities of $\bar{x} \in X^*(\bar{A},\bar{b},\bar{c})$ and $\tilde{x} \in X^*(\tilde{A},\tilde{b},\tilde{c})$ given $(\bar{A},\bar{b},\bar{c}) \neq (\tilde{A},\tilde{b},\tilde{c})$ may not coincide, as is the case with the vectors of the optimal estimates. However, practice indicates that the solutions of optimization problems are not especially stable in the great majority of cases.

Finally, in the second version of interaction, i.e., when composing an optimized plan from fragments of different partial optimal plans, the abovementioned problems are even more complicated: there is no firm footing, not only for their formalization, but even for a description in terms more or less correlated with formal schemes.

When the developers of computer systems and specialists in economic-mathematical modeling (all of whom, naturally, want the fullest and quickest possible implementation of their projects in economic practice) look for reasons for the rather incomplete and slow adoption of information-computing technology and models in economic management, they are becoming increasingly convinced that one of the most serious causes of the shortcomings in this field is the imperfection of the existing economic mechanism, and its lack of correspondence with the available technical facilities and scientific methods. By economic mechanism what is actually understood is the realistic environment where the latter are introduced, and the divergences in viewpoints regarding the ways of accelerating the improvement in management through computerization are particularized and accentuated primarily when the theoreticians and practitioners begin to discuss the interactions with this reality. The economic mechanism cannot be abruptly rearranged or improved overnight. There are deep-seated factors underlying it, including social factors. Therefore, an improvement in the mechanism, divorced from the evolution of the social structures, economic thinking, and our society in its entirety, is not possible. Of course, the environment of introduction of information-computing technology and economic-mathematical methods can and should be subjected to deliberate influences in the direction of such changes as would promote a more profitable use of the modern economic management resources. Such changes should be the outcome of progressive, precisely planned measures, each being analyzed from the perspective of the anticipated consequences of its implementation in the interplay with results of implementation of other measures. Of tremendous importance in the successful pursuit of this process is the adoption of the strictest possible methods of economic-mathematical analysis in the solving of such managerial problems of concern to the enterprises and managerial agencies under the present economic mechanism. There are doubtlessly very many such problems, and the direct confirmation of this are the numerous speakers at the 1984 round-table discussion, talking about particular successes in the area of practical adoption of automated systems and economic-mathematical methods. In addition to the immediate impact (at the level of the enterprise or the national economy), such results also have immense value in promoting an enhanced qualification of the staff, both as economic executives and as co-workers of the management apparatus, a change in their outlook and preferences in choice of management methods, and the like.

In analyzing questions of effectiveness of automated systems, we must often deal not only with particular local objects, but also the principles of selection of solutions and general development trends. Here, naturally, one cannot make do with conventional economic computations, based solely on comparison of expenses and results in monetary terms. The process of adoption of information-computing techniques and economic-mathematical methods inevitably "goes to the heart" of management, exerting a significant transforming influence on it, but indirectly promoting a transformation of the entire economic structure through mediating, at times hidden and hard-to-verify factors. The choice of this trend as one of the first priorities in upgrading the entire system of planning and management of the national economy is dictated, foremost, by considerations of substance and quality, which can by no means be reduced entirely and definitely to quantitative terms. This is a historically conditioned trend, the necessity of which follows from comprehensive analysis of the problems of socioeconomic and scientific-technical development of the country.

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CENTRAL TASK COMPLEX OF THE AUTOMATED CONTROL SYSTEM FOR PLANNING CALCULATIONS OF THE USSR GOSPLAN: RESULTS AND FUTURE PROSPECTS

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 22 No 5, Sept-Oct 86, pp 812-819

[Article by V. V. Shcherbinkin and Ya. M. Urinson]

[Text] The design and introduction of the central task complex (TsKZ) of the USSR Gosplan automated control system for planning calculations (ASPR), begun in 1981, were essentially the fruit of a well-defined trend in scientific research involving the improvement of planning calculations. The foundation of this trend is the concept of applied interdepartmental simulation and utilization of modern data processing tools [1-3]. It became evident in the late 1970s that the problems of effective utilization of interdepartmental models in planning calculations were far exceeding the bounds of the models themselves (as such), and moving increasingly into the methodology and techniques of overall planning. How can the principle of planning on the basis of needs be implemented in practice? How can physical and cost proportions be reconciled in economics? How can scientific-technical progress be quantitatively factored into future planning? The answers to these and a number of other critical questions confronting the developers of interdepartmental models could only be found in the context of a more expansive and comprehensive approach to the modernization of planning calculations. At the same time, the ideas of interdepartmental simulation were creating the general methodological and informational foundation of this approach, since they possessed the essential attributes of an integrated, self-consistent system and had been sufficiently worked out. Thus, the transition from development and use of individual interdepartmental models to the creation of an integrated system of economic planning tasks on such basis became the logical sequel and development of this trend.

The request for proposal to design and introduce the TsKZ ASPR called for the development, trial operation and actual running of several hundreds of economic planning problems, to be solved in the general, balance, and sector divisions of the USSR Gosplan during the formation of the future development plans of the economy, over a period of five years. Experts from scores of scientific research and design organizations of the USSR Academy of Sciences, USSR Gosplan, the ministries and government offices were summoned to carry out this project. The coordination of their efforts was based primarily on the principle of "top-down" planning. This principle has been embodied both in the decisions made and in the preparation of the corresponding instructions and procedures standardizing the format, contents, and project sequence for each task of the complex.

A crucial decision for the system during this time was the adoption of a unified nomenclature of the complex, encompassing 218 kinds of industrial and 17 of agricultural products, 29 ministries and 34 sectors of industry and the economy. This nomenclature, based on the existing system of classification and codes of the ASPR, represents the basic alphabet of the central complex and the standard adopted for interaction of its constituent tasks.

Another major step placing the design of the complex on a firm practical footing was the centralized development of the information interchange formats for each task of the complex. Regardless of the fact that several of the formats put forth "from the top down" subsequently received significant revision "from the bottom up," they still provided the methodological and informational unity of the system, as well as the "point of reference" about which all later activity unfolded.

The functional capability of the central task complex was first verified during the trial operation in 1983. This enabled a working out of the basic methodological, informational, technological and organizational principles of solving the economic planning problems of the complex, and at the same time produced substantive results regarding the evaluation of the fulfillment of the 11th Five Year Plan.

At present, the complex has been adopted in actual operation as part of the second stage of the ASPR of the USSR Gosplan. It was actively employed in the writing of the draft of the Basic Guidelines of Economic and Social Development of the Country for the Years 1986-1990 and the Term Up to the Year 2000, as well as the preparation of alternative versions of the draft of the 12th Five Year Plan.

Summing up the results of the five years of creation and operation of the complex, we may point out that: 1) in the course of development of the complex, the principles and organization of the design of large-scale computer information systems were worked out; 2) on the foundation of modern information processing, a technology of planning calculations has been implemented which takes into account the specifics of coordination of planning decisions, the interplay among various aspects of socialist reproduction on an expanded scale, and the informational, temporal and organizational structures of the planning process.

Today, the central task complex of the ASPR of the USSR Gosplan is a vast complex unifying the subsystems. It includes 258 economic planning tasks, to be solved by computer in 37 departments of the USSR Gosplan. The table shows the distribution of these tasks among the groups of subsystems and project divisions of the plan. The allocation of tasks among the subsystems is in the nature of a pyramid--the base of the complex is formed by the tasks of the sector subsystems (199 tasks or 77 percent of the total), after which come the tasks of the resource balance (38, or 15 percent) and the general functional (13, or 5 percent) subsystems, and the pyramid is capped by the tasks of the General Economic Plan subsystem (8, or 3 percent). The distribution of tasks among the divisions of the plan is distinguished by relative uniformity, which stems from the "equivalent treatment" accorded to the various indexes of the plan.

The preceding characterizes the TsKZ ASPR principally from the quantitative aspect. Among its qualitative attributes, we must first of all note the presence of a whole variety of resources, foremost of which are the methodological ones, which integrate the individual tasks into a system.

The balance method is paramount in the construction and integration of the tasks. The constructs of the balance method represent, explicitly or implicity, all the basic aspects of production on an enlarged scale: needs and resources, indexes of effectiveness of production and distribution priorities, replacement and freeing up of resources, intensity of interchange operations, and so on. The balance method finds its practical embodiment in such tasks of the TsKZ as the determination of need for products of a sector, the development of intersector balances in physical-cost and consolidated cost terms, single-product material balances, and so forth. Directly involved in the development of the balances are 169 tasks of the TsKZ, including those of the plan divisions of production, capital construction, and logistics. Not only are the limits of applicability of the balance method enlarged in the TsKZ, but a heavier functional workload has been placed on it. Besides the traditional balance distribution functions, the balance method in the TsKZ handles evaluation of future needs for products, analysis of consistency of physical and cost indexes, and checking of the correspondence between the scheduled production volumes and the resources, end requirements, and gross outputs.

The functional layout of the TsKZ stipulates that the intersector balance models be the instrument of coordinating the indexes of the various plan divisions at the general economic level. The aforementioned additional balance functions are largely related to this. Within the TsKZ there are two types of intersector model: consolidated cost models and a physical-cost expansion model. The former are combined into a complex of consolidated cost intersector models (KMM) [4], which includes a universal static model, semidynamic models with direct and inverse recursion and two dynamic models with variable configuration, and a "lag" [lagovaya] model. Both dynamic models are optimization models. The KMM also has a unified information base for all models (reported data going back to 1960, current information, planning and forecasting data, analytical results), equipment for actualization of such, as well as the necessary reference and service apparatus. The KMM is used in a point-to-center interaction. With the consolidated intersector models, the macroeconomic proportions of the economy are analyzed in the TsKZ.

The model of physical-cost intersector balance (NSB) provides a more detailed coordination among the various divisions of the plan [5]. Due to the special

Allocation of Tasks of the Central Task Complex
of the ASPR of the USSR Gosplan

Subsystems	Project Divisions of the Plan							
	Basic Indexes	Production	Capital Construction	Labor and Staffing	Net Costs and Income	Logistics	Other	Total
General economic plan	3	2	2	-	-	1	-	8
General functional subsystems	6	-	2	-	-	1	4	13
Resource balance subsystems	-	-	2	2	3	29	2	38
Sector subsystems	21	54	46	32	20	24	2	199
Total	30	56	52	34	23	55	8	258

part played by this model, increased attention has been devoted to its software implementation in the TsKZ [6]. As a result, the NSB has been used to create a rather extensive information and computing system (IVS NSB), enabling the performance of reference functions on demand of the users in interactive mode, formation of the necessary files from the TsKZ data base and solving of a system of large-dimension equations, storage of the results of analysis alternatives, printout of various tables, comparative analysis of indexes in interactive mode, editing and checking of information kept in the data base, and so forth.

Of major importance to the present implementation of the IVS NSB are three features: flexibility or adaptability; interactiveness; possibility of multiterminal operation.

Flexibility is achieved, first, by the modular design of the system, allowing its component parts to be expanded and modified without infringing the functional integrity; and, second, by creating special "tuning" mechanisms (interfaces) at the various levels of the IVS NSB. One of these, for example, involves the structurization of data and assists in the conversion from substantive economic categories to the rigorously classified system of indexes that are handled by the formal computer facilities. Another enables a variation of the composition and form of the equations of the NSB model. Other interfaces also exist, e.g., one for user access to the data base.

The qualitatively higher level of working with the NSB is also due to the interactive mode. Direct real-time access of the users to the data, alongside a clearcut system of sanctions and a reference procedure apparatus, substantially improves the efficiency and the degree of "comfort" of the work process.

An important characteristic of the IVS NSB is the possibility of several users simultaneously working in interactive mode, with subsequent interchange of data. Relying on modern software (in particular, the operational system of virtual machines), such modality creates ample prospects for automation of communication functions, which constitute a very sizable proportion in the process of developing a plan.

While on the economy level the integrating functions in the TsKZ are fulfilled by the intersector models, on the sector level this is done by realization of a typical task composition, including: the need for products and services of the sector by the national economy; the balance of production plant; the volumes of production of products in physical and cost terms; the utilization of primary industrial-production assets; the need for capital investments; the labor productivity, work force, and wage fund; the net cost of products (services) in terms of technical-economic factors and elements of expenditure; the need for material-technical resources. Abundant practical experience with integrated automation of the development of a five year plan draft has been built up over the course of implementation of the sector tasks of the TsKZ, which should be generalized, analyzed, and disseminated.

The functional layout of the TsKZ stipulates that one of the basic definitions on the sector level be the need of the economy for specific types of product. The analysis of all indexes of the sector plan should be geared to maximization of the meeting of this need, taking into account the limits placed on the resources. Depending on the specific situation, the sequence and techniques of solving the problems may differ. All of this requires an appropriate flexible and efficient technology, including information, software and hardware. Such has been achieved with the minicomputer Iskra-226, in which 128 tasks of the sector subsystems (64 percent) are run. Given their methodological uniformity, the trial model of the TsKZ made extensive use of the practice of borrowing typical formulations (in particular, 74 of the 82 tasks of the TsKZ in 11 machine building subsystems were typical). The principle of integration of the tasks of a sector subsystem has been realized most fully within the so-called base task complex [7].

It must be pointed out that the difficulties involved in computer formulation of the individual tasks in different sector subsystems will be different, reflecting rather closely the objectively existing problems of planning. These have been sizable, for example, in the determination of the need for products of a sector by the economy, particularly in the case of the machine building subsystems. For the fuel and power complex, it was not possible to automate the analysis of labor and product net cost. In the light and food industries, the chief problems involved determining the need for material-technical resources. There were virtually no problems in the computer translation of the tasks of planning the production of products in physical and value terms.

An interesting feature, in our view, is the trend in the TsKZ to use ~~of~~ minicomputers as a means of extensive editing of the respective indexes. This affords the user the opportunity of calling up tables with the necessary data in interactive mode from the local information fund onto a display screen, entering certain changes in them, and then either sending them on for printing in conventional format or recording them in the necessary standards on magnetic tape for the purpose of transmitting this output information to the consumers. It should be noted that such trend to use of computers is dictated not simply or not so much by the existence of unsolved procedural problems in the planning of the individual indexes. To a much greater extent, it is associated with a deliberate automation of those planning functions that are not computational--the analytical, coordinating, communicative functions, the preparation and editing of text documents, and so on. Given the fact that a limited number of planning tasks (and as a rule, relatively simple ones) are implemented by strict formal algorithms, there is undoubted importance in the creation of means of automation of their expert solution.

Rather interesting local facilities on the sector level have been created during the course of working with the TsKZ. This involves, for example, the realization of the base task complex in the subsystem Chemical and Petroleum Machine Building (developer the NIIPiN) in the minicomputer Iskra-226, the creation of a local information fund and facilities for using it in the subsystem Fishing Industry (developer the ASUrybproyekt), the use of the interactive system Niva in planning and analysis in the subsystem Agriculture (developer the USSR Gosplan), automation of the sector tasks of the subsystem Construction Materials (developer the VNIIESM), and so on.

Wholesale running of the tasks of the sector subsystems in minicomputers has aggravated the technical and technological problems of interchange of information between them and the computers of the YeS series. The presently adopted procedure for interchange of data on magnetic tape is not satisfactory. Yet the facilities developed within the TsKZ for solving the sector tasks (including the local information funds, the facilities for using them, the data interchange formats, the start-to-finish nomenclature, and the like) create a solid foundation for construction of a unified information and computing network. They can and should form the basis of organizing automated work stations (ARM) for the planning worker.

The prospects for development of the TsKZ mainly involve further evolution of its full array of services and solving of the problems arising at the present day.

In terms of methodology, the most urgent problem is the limited involvement of the tasks of the subsystem Science and Technology in the TsKZ. The difficulties in this case are largely attributable to a certain isolation of this division of the plan. This isolation is characteristic of both the organizational aspect (the technical departments of the enterprises, the scientific production associations, the executive production associations, the research and design institutes of the sectors, the State Committee on Science and Technology, the State Panel on Science and Technology, the State Committee on Inventions, the All-Union Council of Scientific Engineering and Technical Societies, the All-Union Society of Inventors and Rationalizers, and other organizations, on the one hand, and the planning departments, the economic planning authorities, and the subdivisions of the Gosplan, on the other) and the methodological planning arsenal of the scientific-technical program (NTP). Alongside the recognized advantages of the program-goal method of planning (specificity of the programs, their focus on a particular problem, integration, possibility of staggering the resources and the results over time and space, and so forth), a necessary condition for its successful implementation is compatibility with the traditional sector-address economic planning. The most natural means of such compatibility are the standards of effectiveness of resource utilization. Through just such system of standards (particular, consolidated, physical, value and other standards) and, moreover, the balances developed from them (products, plant, capital investment, labor resources), the planning of scientific-technical progress can be brought into intimate relationship with the other divisions of the state plan. Unfortunately, at present the tasks functioning in the subsystem Science and Technology are primarily of an information reference nature.

Another, no less important problem in the TsKZ is the determination of the need for products of a sector. The responsibility of the ministries and government offices for studying the need for particular products has not, in the majority of cases, found expression in systematic, carefully organized, planning activity. Many of the sector departments of the USSR Gosplan are not even ready to undertake such work, either organizationally or methodologically. Characteristically, the decisions made here are not generally applicable to all kinds of products. A specific-sector approach is needed to define the specific factors determining the need for a particular kind of product by the economy.

We also require further methodological work on the finance aspect of planning, an increased representation of the nonproduction sphere in the TsKZ, and a more decisive role for the indexes of quality of life. Financial planning should become an active tool of steering the economy, supplementing and (in certain areas) replacing the planning in physical-material terms. The individual elements for such a tool have been created in the TsKZ--primarily, the consolidated specific outlays of resources (in physical terms) per million rubles of value of products and capital investment, the model of financial circulation, tied into a unified system with the consolidated intersector models, and so forth. To a certain extent, these allow the need for consistency between physical and value aspects of social production to be factored into the planning analysis. In an environment of upgrading the economic mechanism, the role of financial control levers is greater, and therefore we require a substantial enlargement of the arsenal of financial models routinely used in the TsKZ and organization of closer interaction between the ASPR and the automated system of financial computations (ASFR).

Still another of the directions of improvement in the methodology of the TsKZ concerns the planning of the development of the nonproduction sphere and the growth in the standard of living of the population. At present, information as to the target indexes of the welfare of the people is exogenically specified and used to determine the volumes of resources allocated to the social sphere. The TsKZ does not consider the reciprocal influence of this sphere on the effectiveness of production and the solving of balancing problems, nor does it evaluate the necessary level of development of the individual nonproduction subsectors. Furthermore, the development of the indexes of standard of living and social evolution remains scattered over many subdivisions of the planning agencies and to a large extent is a matter of recording facts. At the same time, there exists not only an urgent need, but also the objective possibility (experimentally refined methods and models, an information base, etc.) for strengthening this part of the planning analysis within the TsKZ. As a result, the role of planning the standard of living and the social evolution in formation of the dynamism and proportions of economic growth should be amplified.

Among the general procedural questions, we must single out the problems of integration between modes and between levels of the ASPR. Integration between modes aims at producing uniformity among the long-term (achieved by creating an integrated complex of balance sheet computations), medium-term (the TsKZ), and annual planning processes. Integration between levels proposes to automate the interchange of TsKZ data with collateral, external systems. There is a genuine need for such interaction, particularly in justifying the requirement for products by the national economy. The experience of the socialist countries (e.g., the GDR) testifies that a system of requirement computations can be built, covering a range from the enterprises up to the central planning agencies.

The development prospects of the TsKZ software depend to a large extent on the concept of a distributed data base. The quality of distributiveness of data "brings it closer" to the users and, consequently, greatly improves the efficiency of the activities, as well as the level of reliability of the information. The realization of this concept requires a clearcut standardization of the data flow, data structurization, and a uniform formalized description. Much attention will be devoted to upgrading the forms of information interchange adopted by the TsKZ. In particular, an urgent question (in our view) is the use of the formats adopted for development of the individual material balance sheets in the capacity of the principal source of input data in the TsKZ at the corresponding stage of planning.

Large reserves exist in the modernization of the TsKZ technologies. These are expected to provide a broad spectrum of information and computational services at the level of the specific users, or planning workers. This requires a concentration of effort, not only on the issues of developing ARM from Soviet personal computers and combining them into a unified network, but also on the creation of information reference systems of various levels and facilities to monitor and control the functioning of the TsKZ. All these assets should be strictly oriented to the specific users. In future, the functioning of the TsKZ will be implemented as an interaction of ARM of the planning workers on a unified procedural and informational basis. This will allow not only an increase in computational resources made available to the planning workers, but also enlarged communication possibilities at their disposal.

Still another range of issues concerns the problems of organization of the functioning of the TsKZ. For large systems like the TsKZ, questions of effective, flexible and reliable organization take on paramount importance.

In particular, the organization governs who makes the planning decisions and in what manner: on the basis of computations of the corresponding problems in the TsKZ or on the basis of different information (in which case the reliability of the TsKZ data is diminished); how the urgency of data is ascertained and checked; how the flow of information is monitored; and so forth.

During the course of the design, trial run and actual implementation of the TsKZ, certain forms of organization and methods of control of its functioning have materialized. These include determination of responsible parties for each task of the TsKZ, classification of tasks, development and approval of a computation run-time schedule (regulating the information flow, the information suppliers and consumers, the time frame of incoming data) as an organic component of the procedure of planning development. A practice which has justified itself for the phase of running the computations is the creation of work groups, combining specialists from the Scientific Research Economic Institute and the Main Computer Center with the responsible parties of the sector and general divisions of the USSR Gosplan. At the same time, it must be admitted that certain problems in the area of organization of the functioning of the TsKZ remain unsolved. These concern the procedures for reconciling points of difference between specialists of different subdivisions regarding certain planning problems, encouragement of effective and active utilization of the support facilities, and so forth.

Improvement of the economic mechanism places new demands on the practice of planning. As pointed out in the policy report of the CPSU Central Committee at the 27th Party Congress, "The Gosplan and other economic agencies should concentrate on future planning issues, assuring a proportionate and balanced development of the economy, implementation of a structural policy, and creation of the economic conditions and stimuli for achieving the maximum end result in every niche of the economy" [Materials of the 27th Party Congress, Politizdat, M., 1986, p. 34.] These requirements involve a definite transformation of the array of procedures and technologies for development of the draft of the economic and social development plans, including the facilities of the TsKZ ASPR of the USSR Gosplan. The changes initiated during the course of this process affect both the TsKZ as a whole (e.g., a stronger functional role of long-term finance standards), and its individual tasks (in particular, substantial changes in the tasks of the subsystem Agriculture, associated with the formation of the Gosagroprom and the adoption of the corresponding resolutions regulating the planning of its activities.) At the same time, the fundamental operating principles of the TsKZ remain unchanged, and the flexible adaptable facilities created on this basis grant the possibility of the necessary rearrangement and modification.

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CSO: 1863/39

TERRITORIAL PLANNING AND MANAGEMENT: PROCESSES OF INTEGRATION IN THE AUTOMATED CONTROL SYSTEM FOR PLANNING CALCULATIONS OF THE UKRAINIAN SSR GOSPLAN

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 22 No 5, Sep-Oct 86, pp. 850-855

[Article by M. T. Matveyev and V. V. Kiyan]

[Text] The completion (for the most part) of the first major stage of creation of an automatic control system for planning calculations (ASPR), or the automation of computations, and the transition to the second stage, or integration of planning calculations, confront the developers of the ASPR and the planning agencies (as the users of the system) with a variety of new problems of a methodological, program-mathematical, informational and technological character, deriving from the qualitative alterations in the planning process in the setting of an integrated data processing system (ISOD) [1]. The solution of the new problems requires a study and generalization of the experience in creation of the ISOD fragments in the ASPR, already assembled during the development of its first and second phases.

In the ASPR of the Ukrainian SSR Gosplan, the individual information and computation processes were integrated even during the first phase of creation of the system. The development of the ASPR of the Ukrainian SSR Gosplan in the 10th and 11th five year periods was founded on a quite extensive automation of the formation of all critical departments of the current and future plans [2]. A characteristic feature of the ASPR of the Ukrainian SSR Gosplan is the fact that it forms the foundation of tasks which are oriented toward calculation alternatives, followed by production of draft documents of the plan. Connected to these tasks, which constitute the foundation of the system, are analytical, forecasting, information search and other computations producing supplementary information needed to validate the developing plans. Gearing the computerized calculations to the needs of specific subdivisions and specialists of the planning agency has played an important part in adapting the tasks of the ASPR to the organizational and technological process of plan development, although occasioning a certain fragmentedness of the system. Use of the computer to automate calculations within the individual subject fields is combined with traditional methods of coordination, agreement, and balance of the calculation results at the interfaces of subject fields. Integration of the tasks within a subsystem, which has been extensively pursued in the 11th Five Year Period and is manifested as an interrelationship of tasks through common files of initial information and typical algorithms for their processing, has raised the effectiveness of the automated calculations, but has not provided sufficient utilization of the logical-computational potential of the computer in carrying out the processes of mutual coordination and agreement of different parts and divisions of the plans.

A number of critical organizational-technological and methodological problems of utilization of computer technology in planning were also left incompletely solved during the first phase of development of the ASPR, including the integration of the technological processes of information processing at the computer center, bringing them up to an industrial scale; integration of the software for purposes of standardization and faster preparation of programs; creation of a unified automated control system (ASU) for the process of development of a plan under the aspects of contents and technology; modernization and quickening of the system design process itself.

In the 11th Five Year Period, an effort was undertaken in the ASPR of the Ukrainian SSR Gosplan to develop a strategy for functional integration of the system, enabling an interaction of informationally related calculations within the computer on the basis of a unified technology of plan development at the executive offices.

Integration of the technological processes of data processing at a computer center is expected to minimize the number of appeals to information processing. In other words, a technology of the computational process should be created, managed by the specialized subdivisions without calling upon programmers and suppliers to run the computations in accordance with previously designed problems.

The need for a system to manage the processes of plan development is dictated by the functional integration of the system, which is a consequence of the increasing relationships between problems and the need to investigate them within the framework of a unified computer-based planning technology.

Practical optimization and experimental verification of the decisions to integrate the information and computational processes in the ASPR of the Ukrainian SSR Gosplan were carried out on the basis of creating a central task complex (TsKZ). The object of the functional integration in the TsKZ ASPR of the Ukrainian SSR Gosplan is the calculation of the production indexes (for the most important sectors) and the end use of the social product of the republic on the bureaucratic, sector, sector-summarized (in physical and value terms) and economic levels of the republic (in value terms). The choice of the object of integration permitted the implementation of the critical "vertical" linkages between the sector-summarized and the economic analyses of production and consumption of the social product within the TsKZ, as well as a variety of basic "horizontal" correlations of volumes and structure of production of products by individual sectors (projected on the republic level), indexes of production of social product and its end use, physical-material and financial proportions of consumption. In the process of further development of the ASPR, the task complexes of production resources and quality characteristics of production effectiveness (among others) should be incorporated into the system of computations of such indexes.

In order to enable a comprehensive survey and quick run-through of an abridged, mutually coordinated, integrated version of the draft plan, a compact system of formation and balancing of basic indexes of the draft plan has been included in the TsKZ as a synthesizing and balancing element. This is the so-called exit (output) problem (VZ) of the TsKZ.

To carry out the functional integration of the TsKZ, network structure models of different degrees of consolidation were selected: networks of the relations of the tasks (the nodes are the tasks or the complexes thereof, the lines are the information linkages) and algorithmic networks of the relations of the indexes (the nodes are operators for evaluation of the indexes, the lines are the information linkages.)

The network of task links realizes three types of relations between tasks: "input-input", "output-input", "output-output" and is used to construct a base of informationally connected task indexes (TsKZ integration nuclei) under conditions of differences in the forms of presentation and the methods of encoding of the input and output information of the coupled calculations, as well as control the sequence of solving the different types of problems with the appropriate software.

The TsKZ operates in two basic modes: independent problem solving (off-line solving by means of various initial data and subsequent appearance in the integration nucleus of conflicts and errors in the values of similar indexes between the inputs and outputs of the problems being informationally coordinated, as well as isolation of defective conflicting records and sending of these to the users); sequential problem solving (running of the problems in a time-ordered sequence, followed by transfer of output data of one problem to the input of another across an integration nucleus within the computer.) There are also two formats: abbreviated, with either onetime running of computations in a problem chain or discovering of conflicts in the numerical values of similar indexes in the problems, followed by entering corrections into the data of the TsKZ operating procedure external to the system; complete, in the form of an organized iterative process of successive reconciling of conflicts between indexes with repetition of the calculations on the basis of a movement from input to output of a network of interrelated problems, or from output to input.

The TsKZ task link network under discussion will remain open, to be filled by other tasks of any given class, or can be cut back at any given time when certain calculations become obsolete.

The algorithmic index link networks have been certified for the VZ TsKZ and can describe practically all direct planning calculations of the ASPR in the form of a network model of planning technology (SMTP) for a particular group of indexes. It is assumed that the abstract SMTP possesses: an algorithm and programs for batch running of the calculation, putting out the finished planning documents and defective records of discrepancies between the model parameters (if applicable) to the user; algorithms and programs for operational "refinement" of the calculation results in batch mode to the condition desired by the user in computer interaction; a standard technology of information processing in batch and interactive modes; standard utilities for managing and maintaining the model itself in the computer; standard technological facilities for production of a plan on the basis of the SMTP. Apropos of the SMTP, we must clearly distinguish between (at the least): 1) the working technology of production of a plan, simulated by the SMTP; 2) the technology of information processing at the computer center, used in the facilities servicing the SMTP.

Given the fact that direct planning computations constitute around 60 percent of the ASPR, the SMTP by virtue of the aforementioned standard features is capable of integrating the bulk of the ASPR of the Ukrainian SSR Gosplan in the program, technology (information processing and formation of the plan), and also the functional respect. Moreover, certain features of the practical formation of the SMTP enable an integration of the system design.

Thus, the SMTP comprises a description of the sequence of technological operations of production of a plan, with the informational linkages between them. The typical formulation of an SMTP includes the rules specifying the network of transformations of economic indexes, as well as the network processing algorithms in batch and interactive mode between the planning analyst and the computer system.

The rules specifying the network of transformations of the economic indexes come down to the methods of describing the nodes of the SMTP, which function as the operators in carrying out the formalized technological operations, usually implemented by the planning analysts in the course of formation of the plan. The lines of the SMTP are automatically drawn by the system. These define the presence of informational linkages between the operators or indexes of the original information and the operators, and specify the sequence of implementation of the latter.

In practice, the SMTP is not constructed in analytical form. To organize the SMTP in the computer memory, there is a special programming language [3], oriented to the nonprofessional user (economist). The simplicity of this language enables the use of such representation of the SMTP, not only by a computer, but also by a human for analysis of the methodological decisions built into the model.

The technological operations of formation of a plan that are realized in a typical SMTP of the second phase of the ASPR of Ukrainian SSR Gosplan include:

computational procedures, carried out by arithmetical operations on vectors, matrices, and individual numbers;

operations of rearrangement and formation of vectors or matrices;

a set of standard technological procedures used to implement typical transformations;

balance verifications;

production of finished plan documents in the form of tables, generally consisting of sections and a certain sequence of indexes in the sections.

The computational operations and the operations of formation and rearrangement of vectors and matrices are self-explanatory.

By standard technological procedures we understand certain algorithms that are applicable to the various indexes, regardless of their economic significance (e.g., the rate of growth of any given index is computed by the same formula.) The collection of such algorithms forms a set $Z = \{z_\alpha | \alpha = 1,\ldots,L\}$, where z_α is the title of the algorithm. The sets Z are worked out for each SMTP to provide a compact description of the models.

The operation of production of finished plan documents entails assigning attributes to the indexes determined by the computational operations or structural transformations, making it possible to "put together" a planning document. The collection of such attributes forms a set $M = \{m_\gamma | \gamma = 1,\ldots,G\}$, the elements of which "control" the printout or display of the finished documents on the video terminal.

The operations of realization of standard technological procedures, as well as production of finished planning documents, may not form independent nodes of the SMTP, but be combined with other operations as a single node. For example, if a standard operation from the set Z is to be performed with an index P, evaluated by the formula $P = f(X)$ and entering into a particular planning document described by the elements of the set M, this can be described at a single node of the SMTP as:

$$(M,Z) \rightarrow P = f(X),$$

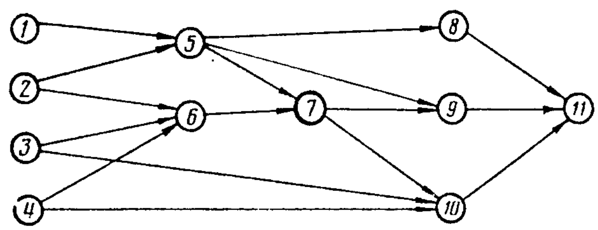
where the arrow indicates the existence of "control" of the index P on the part of the elements of the sets M and Z.

In the general case, the above expression is a generalized notation of a node of the SMTP, or an operator of the model. The parameters M and Z may be absent from it. If M is missing, then P is evaluated in the system and can be used for further computations, but is not printed out.

The technological operation of balance verification is interpreted in an SMTP as a method of agreement of indexes, i.e., the values of the identical index as computed by different methods or represented in different sections of the plan, or under the supervision of many executives at the planning agency, or whatever, should be consistent. Such approach to balance corresponds to the concept of agreement of values of indexes in [4], although being different in realization. The balance verifications are not described by special nodes of the SMTP, but are standard features of the processing algorithm of the model as a condition for checking the agreement of values of like indexes in the system.

Let us examine the general scheme of making a calculation and the scenario of interactive "refinement" of planning documents on the basis of an SMTP, using a hypothetical example.

Let there be an SMTP organized in the computer memory, which can be graphically depicted as shown in the figure.



Graphical depiction of a hypothetical SMTP

For simplicity, we assume that only one index is formed at each node of the net. At the start of the computations, the processing of the graph is done from left to right. As a result, the values of all the indexes are determined and the plan formats filled in.

In the interactive mode, the planning worker (user of the system) has the option of correcting on video screen any given index computed at the starting, middle or end nodes of the graph. This gives rise to the problem of preserving the mutual consistency of values of the indexes, achieved in the starting calculation. We consider the most general case: correction of an index at the middle of the graph, e.g., node 7.

The following distribution of functions between the user and the computer is assumed in the process of correction of value of an index.

The user: 1) "declares" the need for a correction by indicating a new desired value of the index and 2) makes a decision to implement the correction.

The computer: 1) "shows" the user the consequences of the proposed modification and, if the user is agreeable, 2) "prepares" verified alternatives of the proposed correction.

The full procedure will resemble the following.

The consequences of the proposed correction are shown to the user by recalculating all the indexes located at nodes depending on the 7th node, namely, nodes 8-11, in two rows: WAS and BECOMES. If the user agrees with the resulting changes, the process moves on to verification of the proposed correction.

The screen displays the values of the indexes calculated at nodes 5 and 6 in two rows: IS and MUST BE. The user must eliminate the conflict by filling in the rows MUST BE. If the conflict is eliminated by using the index of node 6, for example, then this index will be treated as a corrected index in the network, with further determination of consequences, carrying out of a new verification, and so forth. The process continues moving from right to left through the network of linkages of indexes until there are no more nodes with input lines. A more complete description of the interactive scenario is presented in [5].

On the basis of the described principles of construction and use of the problem linkage networks and the index linkage networks, which have been tested within the TsKZ of the ASPR of the Ukrainian SSR Gosplan, we can draw the following conclusions regarding the future prospects of integration processes within the ASPR of the Ukrainian SSR Gosplan.

1. The problem linkage network and the integration nucleus based on it make possible a flexible functional integration (without rigid information linkages) of the tasks of the ASPR, regardless of the methods of their solution or the software employed.

2. The problem linkage network can serve as the basis of organizing a control of the computational process and a regulation of the technological phases of plan formation, due to the presence of complete information for implementation of these functions in it.

3. The subsuming of the extensive class of problems of direct planning computations under an SMTP renders these problems absolutely uniform in respect of information processing at the computer center. As a matter of fact, the diversified functional-substantive formulations of the problems are incorporated into network models, the processing algorithms of which are in no way dependent on their basic components. Such integration of the technology of information processing provides a real possibility of creating a specialized subdivision handling the computational work for the ASPR of the Ukrainian SSR Gosplan, freeing the programmers and development engineers from this activity. The computations handling subdivision will not be required to master each newly developed task, since in respect of technology the new tasks will be no different from the current ones.

4. The SMTP enable an integration of the software of the largest group of ASPR tasks, reducing the great variety to a set of typical programs supporting the technological process of information processing at the computer center.

5. One of the most important effects of adoption of the SMTP is the integration of the processes of design of ASPR problems by combining the activities of the user (plan developer), the designer of the functional components of the ASPR, and the programmer during the problem development phase. As already pointed out, the elementary description language of the SMTP can be used by a design engineer with no special training. The resulting model is perfectly understandable to the plan developer. Any given change in the calculation procedure or presentation format of the results comes down to correcting the model, which can be done by the user or the designer, and which represents a simultaneous change in the particular problem solving program. Since it turns out in this process that neither the user nor the designer, describing the model or the calculation procedure in familiar terminology with the SMTP formation language, send anything to the programmer for further work, the project documentation for the problems is itself greatly simplified. The SMTP of a particular group of indexes is a thoroughly complete document for the problem, equally comprehensible to all three types of specialist. In such a setting, it may not be necessary to develop the GOST-stipulated documentation for the problem, although this point requires further study.

6. The integration of the technology of the planning process involved in formation of plan documents is implemented directly in the SMTP, since the various types of activities of the plan developer are combined into a single process, supported by the model. Because the typical model remains open for incorporation of other technological operations, this process can be expanded.

7. The functional integration on the basis of SMTP is quite evident, as the incorporation of any given group of indexes in the model requires a simultaneous informational and algorithmic consistency, both among themselves and with the other indexes already described in the SMTP. In the model itself, the indexes with the established linkages interact automatically through the standard features.

An expanded application of this approach to integration of the ASPR of the Ukrainian SSR Gosplan is scheduled in the 12th Five Year Period by identifying several integrable blocks of the system, forming a nucleus of integration in each of them (except the TsKZ complexes for production of the critical indexes of a territorial cross section of the plans, the development of a draft plan for science and technology, for capital construction in the context of adoption of the Unified System of planning of capital construction, and so forth), and also by expanding the subject range of calculations based on the index linkage network.

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CSO: 1863/39

INFORMATION SCIENCE AS A BRANCH OF THE NATIONAL ECONOMY: CHARACTERISTICS, DEVELOPMENT PACE AND TRENDS

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 22 No 5, Sep-Oct 86, pp. 899-902

[Article by N. N. Moiseyev and Yu. N. Pavlovskiy]

[Text] The evolution of the structure producing material goods has attained such state in recent time that it is necessary to include information (in the broad meaning of this term) among the objects of labor, and to regard information science not only as a scientific discipline, but also as one of the sectors involved in the creation of these goods. By information we shall understand any knowledge concerning the processes which have occurred, are occurring, or will occur in nature and society. The physical carriers of information are: the human brain, documents, books, punched cards and tape, magnetic tape and disks, and computer memory in all its forms. By information science in the present article we shall understand the totality of means and methods by which information is collected, stored, processed, transmitted and adapted for use in a particular form. Its value is determined primarily by how necessary it is to the working out of decisions in the economic, political, scientific and other spheres of activity; therefore, we shall also regard the development of the methods of its application in any given decision-making procedure as a part of information science.

Let us discuss the question of the gathering of information, i.e., its origination. Some of the data which we possess require no special gathering facilities. This is information which is directly perceived by our organs of sense. However, most information is specifically obtained by using the most sophisticated technical equipment. Examples of this are the permanently functioning measurement system for fundamental physical constants or physical properties of various materials, the weather prediction service, the reporting and accounting system in the national economy, and so on. This information has both net worth and consumer value.

Certain data are consumed by the production sectors directly in the form in which they arrive. But most data are subjected to additional processing.

Thus, information is an object of labor. Its processing, transmission and storage are done by means of various tools, among which the most important are the computer, the computer software systems, algorithms, decision support systems, automated control systems, data banks, knowledge bases, and so forth. The means by which all of this is accomplished are the means of labor, acting on the object of labor which we have designated as information. This, together with the means of labor, should be considered a part of the means of production at the disposal of society. These means, as well as the people possessing the necessary training, constitute a portion of the productive forces of society, without which modern society and the modern production structure could not exist, just as if power engineering, machine building, or transportation were lacking. We may point out that information science in our definition also includes science, since science is today the principal method of obtaining new data on processes occurring in nature and society.

Information science as a sector of social production, considered in the abstract sense, from the standpoint of its relationships with the other sectors, but without considering its content, is no different from them. Just like the product of other production sectors, the great bulk of information in modern society is a commodity, i.e., it is produced for sale. Information science, in the nature of the interrelationships with other sectors, is most similar to power engineering, but has its own intrinsic features.

The development of the production structure takes place along lines of greater complexity: the nomenclature of produced commodities and the number of enterprises grow, on occasion there is an increase in the number of sectors, and this is closely related to an increase in labor productivity. On the one hand, such increase occurs largely by virtue of a widening of the internal relationships of social production, its specialization and structurization. On the other hand, economics is always influenced by the flood of proposals for production of new kinds of goods and services. The implementation of these proposals, resulting in an increased variety of goods, indirectly redounds on the formation of new sectors and induces a growth of labor productivity in the existing sectors. Let us illustrate the relationship between labor productivity and complexity of the production structure by the following data. In 1928, the index of labor productivity in the industry of the USSR (taking the figure of 1913 as unity) was 1.22 with 11 narkomats (ministries), in 1940 the respective figures were 3.8 and 29, in 1945 - 4.3 and 31, in 1947 - 4.8 and 34, in 1954 - 7.72 and 50 [1,2, p. 532, 537]. These data allow us to infer that the relationship between the labor productivity and the indexes describing the complexity of social production is almost linear. The following analysis will be based on this assumption, which we shall later moderate. Thus, labor productivity can be characterized by quantities describing the complexity of social production, e.g., the number of sectors in the national economy.

Owing to the increasing number of sectors, the average share of workers in the individual sectors (i.e., the ratio between the number of workers in the sector and the total number of workers and employees) naturally diminishes over the course of time. Accordingly, the average share of labor (in value terms, for example) contained in the goods produced by the sectors also decreases. However, if we take a particular sector, the share of workers in it and the share of labor realized in the produced goods may undergo different changes.

The characteristic of information science as a sector is the fact that its share of workers is constantly increasing, and in the age of the scientific-technical revolution this increase is proceeding at an ever faster pace. Consequently, the share of labor incorporated in the commodities of information science is also increasing.

We can mention two factors responsible for the sharp rise in specific share of information science in social production: 1) a profound reorganization of the consumption structure is taking place in modern society: information is increasingly becoming an object of end consumption; this tendency will persist in the foreseeable future--more and more people will be interested in information concerning the events, phenomena, and processes taking place in nature and society; 2) the increasing complexity of the production structure, inseparably connected with the growing labor productivity, demands not simply a proportionate, but a much faster increase in the labor expenses in information science. Let us illustrate this by the example of one of the most simple planning models--the intersector balance problem.

From the intersector balance relations, which are a system of linear algebraic equations with given coefficients of direct expenses $a_{ij}, i,j = 1,\ldots,n$, we determine x_i, or the gross outputs in the sectors, assuring given volumes of end consumption y_i.

In order to evaluate x_i from Leontyev's balance model by the present methods, we require an order of n^3 operations of the multiplication type. Assuming that the number of sectors is related to the labor productivity by an approximately linear function, in order to increase the latter we require not simply a linear, but at the minimum a cubic increase in information processing and a quadratic volume of information (since the solution of even one of the most simple planning problems requires a knowledge of n^2 of the numbers a_{ij}).

From the formulas:

$$(n+\Delta n)^2 \cong n^2\left(1+2\frac{\Delta n}{n}\right), \quad (n+\Delta n)^3 \cong n^3\left(1+3\frac{\Delta n}{n}\right)$$

it follows that for each percentage of increase in the labor productivity we require at least a two percent growth in volume of information circulating in the planning system, and a three percent growth in the volume of its processing.

This example, of course, is only an illustration of how an increase in labor productivity results in a sudden rise in the work volume in the sphere of information science. The cubic relationship between labor productivity and work volume in information science, shown by this example, is only the lowest estimate.

The problem under consideration belongs to the class of so-called "polynomially-complex" problems, for which the relationship between the dimensionality n and the number N of operations required for its solution (in the case of large n) has the appearance $N \simeq An^a$, where A and a are certain numbers. Not only these problems, but also exponentially complex problems are encountered, in which the volume of computations increases along with the dimensionality of the problem by an exponential law. Furthermore, a sizable portion of such work involves operational management of the production process and various kinds of coordination. Difficulties are created when the complexity of the production structure increases much faster than a linear function. Moreover, growth of labor productivity is largely attributable to the appearance of new technologies, which are the result of scientific development projects, i.e., the creation of new information about the properties of actual processes. The complexity of the development of new technologies and design of new engineering increases rapidly with increasing complexity of the production structure. In order to clarify just how the work volume W in the sphere of information science depends on the complexity n of the production structure, special investigations are needed. It is clear that the estimate $W \simeq An^3$ is the most optimistic, and that the true value lies somewhere between An^3 and Be^n.

If the relationship between labor productivity (complexity of the production structure) and the work volume in information science has the appearance $W \simeq An^3$, each percentage of increase in labor productivity requires a three percent increment in information science. If the labor productivity in information science increases at the same pace as in the entire production structure, the proportion of workers in information science will inevitably increase, but up to a certain reasonable level. As soon as this level is reached, the growth in labor productivity as a whole in the national economy should constitute no more than one-third of the growth of labor productivity in information science. But if this relationship is exponential, such limitation will be much more severe--the increase in labor productivity in the national economy will constitute a value on the order of (1/n)-th of the growth of labor productivity in information science. This means that the more developed the society and the higher its labor productivity, the more effort required in the sphere of information science for each percentage of growth of labor productivity.

Thus, if no concern is addressed to encouraging the growth of labor productivity in the sphere of information science, the moment will inevitably arrive when the growth of labor productivity in the economy as a whole will be held back by the inability of information science to cope with the increasing complexity of planning, management, design and forecasting. The external characteristics of such situation will be an overloaded administrative accounting and managerial apparatus, inability to fulfill the assignments within the stipulated time, increasing length of the design process and slower rate of introduction of new techniques on account of a long chain of essential coordinations, losses in the economy due to inability to coordinate its various structures, and so on.

The introduction of new information technology, based on the use of computer networks, data banks, information visualization, automated control systems, and decision support systems, takes on ever increasing importance, becoming a first priority.

Thus, in order to sustain the set pace of economic growth, the growth pace of information science must be at least three times faster. This conclusion follows from our adopted hypotheses as to a linear relationship between labor productivity p and the indexes of complexity of the production structure n, and the cubic relationship between the work volume W in information science and n. However, we can arrive at this by much more general and less restrictive assumptions. If, for example, these relationships are linear and $p \simeq Cn^c$, $W \simeq An^a$, where C, c, A, a are certain numbers, then the conclusion as to the necessity of preferential growth of information science requires that a be larger than c.

Thus, the development of information science must lead the way.

Analyzing the evolution of modern information science hardware and the possibilities of its application, it is not difficult to imagine the near future and the consequences which will result. Of paramount importance in the immediate 20–30 years will be, probably, the following circumstances: a) the appearance of computer networks making possible a rapid interchange of information between all the subscribers, where the interchange of information will not be only in digital or verbal form, but also in graphic form; b) rapid growth in information science technology, modernization and miniaturization of the component base; c) the immediate consequence of these trends will be the introduction of a paperless management technology. For example, the reference service will disappear, because all authorized persons will be able to call up instantly on their display any information needed for decision making. The paperless technology sharply intensifies all managerial processes. It is a reserve of substantial increase in the societal labor productivity of the economy as a whole.

In conclusion, the authors believe it is conceivable to imagine the following crisis, which will occur after overcoming the information crisis. In all likelihood, this will be an organizational crisis. In fact, the most important consequence of the described trends will be the creation of a certain informational environment, making information available and establishing contacts between people. The use of this environment promises a qualitatively new level of progression of civilization, but only in a specially organized society, and requires revolutionary changes in the norms of human behavior.

The informational foundation of social development is undergoing explosive change. This will evidently result in the appearance of qualitatively new organizational structures, which might be called a "collective intelligence." The essential organization can only be achieved under conditions of collective ownership of the means of production, i.e., socialism. But this requires the development of entirely new principles of management, interconnectedness, and interaction of the political, social, scientific and production organisms.

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CSO: 1863/39

SECOND PHASE AND DEVELOPMENT PROSPECTS OF THE AUTOMATED CONTROL SYSTEM OF PLANNING CALCULATIONS OF THE LITHUANIAN SSR GOSPLAN

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 22 No 5, Sep-Oct 86, pp. 856-863

[Article by A. A. Vasilyauskas]

[Text] The problems of developing the second phase and the principal trends of future development of the automated control system of planning calculations (ASPR) of the Lithuanian SSR Gosplan are discussed in [1,2]. In the present article, we generalize the experience of its design and examine the achieved level and prospects for automation of the planning in the republic on the basis of the general concept behind the creation of the ASPR of the USSR Gosplan and the gosplans of the Union republics [3-6].

The main attention is placed on the following trends in modernization of the planning process: automation of information processes; multiple alternatives and balance coordination in planning computations; optimization of plan decisions.

Each of these trends is being implemented in stages. Thus, for the FIRST TREND, we may distinguish three successive stages of automation of the processing of plan information: local automation; individual integration; collective integration.

Local automated processing of planning information was implemented as far back as the second generation of computers in the first stage of the ASPR of the Lithuanian SSR Gosplan. In the Minsk type computer, only a batch processing mode was possible, whereby after entering the problem into the input stream of the computer system there was no possibility of operative interaction between the plan developer and the computer. The information fund organized in these machines consisted of an assemblage of local files for the individual functional tasks or complexes thereof. However, already within the first stage of the ASPR of the Lithuanian SSR Gosplan a certain start was made on integration of the processing of plan information through the development and use of universal problem-oriented software: standard procedures for input, transformation of the presentation formats, gathering and organization of information, program modules, and means of generating programs of complex structure from them. The methods of direct planning calculations and the means of registration of their results were also improved.

In the second stage of the ASPR, an individual (for the level of the Lithuanian SSR Gosplan) integrated processing system for plan information was created and put into service. This system realizes an interactive mode, in addition to batch processing, which allows the plan developers to solve the functional problems of the ASPR by themselves in the computer. Having direct access to the resources of the computer system across video terminals, the users can start or interrupt the computation process, enter corrections into the initial data and parameters, and change the boundary conditions or the calculation algorithm. Both direct planning computations or tasks of information search, and tasks based on the use of economic-mathematical methods and models are realized in interactive mode.

The technical base of the second stage of the ASPR of the Lithuanian SSR Gosplan is a two-level computer system, combining a central computer complex of three general-purpose interlinked computers and a complex of microcomputers. The central computer complex processes the stream of batch assignments and services the video terminals of the users in solving the functional tasks of the ASPR in interactive mode, and manages the major data bases of branching structure. Thanks to the presence of the microcomputers in the system, it is relieved of the noncomplicated direct planning computations and the chores of processing the plan documents. Since the configuration of the microcomputers includes video terminals, effective means of data display and storage, as well as user-friendly software, these machines are well suited to the elaboration and solving of problems by the planners themselves. Preparation of data and formalized entry of data on direct magnetic tape are also done by the microcomputers.

On the foundation of the general-purpose computers and the microcomputers, automated work stations equipped with displays have been put into service. A sizable number of these are used directly within the divisions of the Lithuanian SSR Gosplan. Several automated work stations are operating in a collective use mode. The combination of individual and collective modalities allows an increased workload of the displays and computing facilities and a larger circle of users for a limited number of video terminals in operation.

In contrast with the first stage of the ASPR of the Lithuanian SSR Gosplan, the software of the second stage was developed on the basis of extensive capabilities of the operational systems, data base control systems, general-system program packages, typical applied program packages (acquired at the same time as the computers or obtained from the centralized fund of algorithms and programs of the ASPR of the USSR Gosplan and the gosplans of the Union republics.) In this connection, only the software for realization of specific procedures of planning computations, information search tasks, economic-mathematical methods and planning and forecasting models were developed individually for the ASPR of the Lithuanian SSR Gosplan.

The use of general-system and typical software made possible a unified technology of data processing during the solving of the tasks of the second stage of the ASPR of the Lithuanian SSR Gosplan. Initial input, checking and gathering of plan information in the external memory are done by the system

DOCUMENT. The large data bases are managed by the system INES, which provides all necessary technological facilities for creation of information systems. Depending on the nature of the problems being solved, different software are used to carry out the computations, in accordance with the specified algorithms. Thus, the system SChYeT-YeS is used for direct planning computations; a generator of structural transformation programs and a standard applied program package for analysis and forecasting have been developed and are in use. The realization of more complicated algorithms is done with a scientific program package in the languages PL/1 and FORTRAN-4 and the applied program package LP PPP ASU. Using the general-system and standard software enables a substantial cutback in time and labor of the programming stage of the functional tasks.

In order to provide operational access of the users to the information in an environment of multiple computer processing, realized by different types of computers and different software, a unified information fund has been created for the second stage of the ASPR of the Lithuanian SSR Gosplan. This includes a system of data bases, problem-oriented file structures, and information search systems.

The system of data bases includes the data from the records of the economic entitites, general indexes, and text. The data bases of the economic entities consolidate the primary information of the records of the cities and regions of the republic, the industrial enterprises (associations), the construction organizations, and construction projects. The data base of general indexes was originally designed as informational support for the central task complex. However, during the process of its creation and development, it became increasingly a unified source of general information for all functional subsystems. The text data base centralizes the gathering and constantly updates verbal information for a formalized description of data, and integrates the text and numerical information when printing out the results of the planning computations.

The placing of the problem-oriented file structures in a separate group is dictated by the fact that not all information used in the planning computations requires integrated processing and permanent storage in direct-access memory structures. Thus, a file organization of information is sufficient for planning computations done by microcomputer. Even for a general-purpose computer, the layout and maintenance of data bases consume considerable labor of the highly trained specialists and computer resources. As these resources are expanded and the volumes of multipurpose planning information increase, the proportion of file structures in the overall volume of data stored in the computer memory will gradually decrease.

In the second stage of ASPR of the Lithuanian SSR Gosplan, the information search tasks have been placed in an independent subclass. These carry out the logical operations of retrieval and output of information on request of the plan developers in interactive mode. Certain of these tasks have been based on large multipurpose data bases, handling direct planning calculations and calculations which employ economic-mathematical methods and models. Others, because of their special nature, require the creation of specially organized collections of information in the form of files or data bases. Thus, for the interactive servicing of the directors of the Lithuanian SSR Gosplan, an information search system has been constructed on the basis of a specially organized file of tables, containing the basic indexes for the activities of industry, agriculture, capital construction, transportation, individual ministries, and certain other information.

An important trend in furthering the systematization of planning computations in the second stage of the ASPR of the Lithuanian SSR Gosplan is the development of complexes of interrelated planning and forecasting tasks. The majority of such complexes are confined to individual divisions of the national plan. Coordination of calculations in different divisions is done through a central task complex, which includes two types of task. The first is designed to determine the basic parameters of economic and social development of the republic during the stages of development of the basic outlines of the five year and long term plans and formation of the initial data for preparation of draft proposals of the plan in the functional subsystems. The tasks of the second type are used to process the information contained in these proposals and to assure proportion and coordination among the different divisions of the plan.

Collective integration of the processing of planning information (the third of the previously mentioned automation stages) will be brought about during the further development of the ASPR in the 12th Five Year Period and in the long term. However, certain of its elements were already present in the second stage of the system, where the ASPR interacts with the ASU of the ministries and government offices. Such interaction occurred in two forms: obtaining of information on magnetic storage media from the outside ASU; construction of collective data bases. The interchange of information on magnetic media was done during the formation of the basic outlines and projects of the yearly plans and five year plans in certain divisions (industry, capital construction, labor and staffing, etc.), as well as in the process of analysis and supervision of the enactment of the approved plans. For collective use, a data base in terms of the records of the economic entities can be used.

In future, the computer complex of the ASPR of the Lithuanian SSR Gosplan should function as a component of the unified computer network of the USSR Gosplan and the gosplans of the Union republics. At the same time, because of the paramount position of planning in the management mechanism, it should become a central link in the computer network of the republic. This requires an increased capacity of the existing computer complex (through both general-purpose processors and mini- and microcomputers), an expanded network of automated work stations, and a development of remote processing facilities. Even today, remote data processing occupies a significant place in the ASPR. In future, there will be a shift from system to network remote processing architecture. The presence of remote data processors in the computer complex of the ASPR of the Lithuanian SSR Gosplan, linked by communication lines to analogous computer installations of the outside ASU, will provide mutual access to the processing facilities and data bases of the unified automated systems. Collective integration of the processing of planning information also proposes to implement the principles of distributed data processing. Ultimately, there should be a gradual shift to a paperless interchange of information in the process of development of plans and supervision of their enactment.

The SECOND TREND in modernization of planning--multiple alternatives and proportionality in planning calculations--is also being implemented in three stages: proportionality of general planning computations, "internal" and "external" proportionality.

The first stage was implemented as far back as the first phase of the ASPR of the Lithuanian SSR Gosplan in the group of planning calculations for validation of the basic indexes of socioeconomic development over the five year period and the long term, using a system of models [7].

The second stage should provide an "internal" proportionality among alternatives of the yearly, five year, and long term plans of economic and social development of the Union republic, each being coordinated vertically (mutually correlated target and resource indexes) and horizontally (correlation between sectors and between regions). Due to the complexity of the problem, the construction of an appropriate system of multiple alternative computations in perfected form exceeds the bounds of the second phase of the ASPR of the Lithuanian SSR Gosplan. The start in this field, made during the 11th Five Year Period, includes three types of planning and forecasting models: functional; local forecasts; consultative.

The functional models cover certain groups of interconnected indexes and are designed to carry out multiple alternative planning or forecasting computations and to coordinate these. Thus, the following functional models are used to implement the central task complex: macroeconomic national model, economic models for the sectors of the economy, dynamic intersector balance model, model of demographic forecasts, model of labor resource balance, model of monetary income and expenditure of the population, end consumption model, and development model of the nonproduction sphere. For other complicated groupings of tasks and individual functional subsystems of the ASPR, corresponding functional models have been created.

In the central task complex, multiple alternative computations are performed in several stages. First, the indexes of growth of production, number of employed, volumes of capital investment and primary production assets are calculated for the economy as a whole and its sectors. At the same time, different alternatives are analyzed and evaluated in terms of effectiveness of social production and influence of scientific-technical progress on the pace and factors of economic growth. This allows an investigation of such crucial economic mechanisms as the influence of materials consumption of production and norms of production accumulation on the dynamics of national income, relation I and II of the subdivisions of social production, the reproduction structure of capital investments, and so forth.

The indexes obtained on the national level for capital investments and primary production assets in the sector cross section serve as the initial information for the subsequent computations concerning the basic sectors of the productive (industry, agriculture, construction, transportation and communications, distribution and handling, other sectors of material production) and nonproductive spheres. The alternatives of development of the sectors are evaluated to take into account the internal goals of economic growth and effectiveness of production, defining the respective indexes from both the sector and the address (bureaucratic) standpoint. The obtained results are correlated with the indexes determined in the subsystems "General Economic Plan", "Labor and Staffing", "Capital Investments". Decisions to correct the conflicts discovered in this process are made by the planning developers, according to their authority.

The local forecasting models are used to analyze and validate possible values of the individual indexes in the various functional subsystems. They are likewise used to determine certain exogenic parameters of the functional models. For short term and medium term forecasting, there are used trend models, autoregression and regression models, methods of adaptive and structural prognosis; for the long term, the methods of combination prognosis, which couple model-based calculations with expert evaluations of possible future change in the indexes.

Consultative models, which provide extensive information of an analytical nature, are used to validate the integrated alternatives of economic and social development of the republic. For example, macroeconomic consultative models enable a retrospective analysis and particularization of the factors of future development, producing a more total picture of the nature of economic growth. This creates conditions for a rational selection of one of the alternatives of the basic indexes of economic and social development of the republic.

In the future, besides continuing developments in "internal" proportionality on the level of the Gosplan of the republic, it is necessary to create a system of "externally" proportionate, multiple-alternative planning calculations, spanning the levels of the sector ministries, associations (enterprises), cities and regions. The cyclical iterative process of such calculations will enable balanced alternatives of coordinated republic, sector and territory plans of economic and social development. But such system will require even larger and more complicated work in producing planning and forecasting task complexes encompassing the ASPR of the Union republic and the ASU of the ministries (offices), cities and regions; an integration of the methods, models and algorithms used to solve the problems; development of a means of guiding the process of calculations in a unified republic computer network; integration of calculations with plan decision making at the various levels of the national hierarchy.

We know from experience how serious are the difficulties occurring when different economic planning tasks are assembled into complexes within the ASPR. Obviously, even greater difficulties will be encountered in the unification of tasks solved in different automated systems. In designing a multilevel computational system, we must also pay attention to the objective factors which restrict the possibilities of mathematical modeling of the planning processes. Special hardships are created when developing and using models in those fields where the planning process is largely dependent on intuition and experience of the plan developer. At the republic level, additional complications appear when coordinating the bureaucracy, sector and territory cross sections of the plan, and also in connection with other factors preventing the acquisition of reliable primary information for plan decision making.

The THIRD TREND in modernization of planning within the context of the development of the ASPR of the Lithuanian SSR Gosplan--optimization of planning decisions--includes the following stages: local optimization; integrated same-level optimization; integrated multiple-level optimization.

In this, as compared to the other two trends, the achieved results are the most modest. In both the first and second stages of the ASPR of the Lithuanian SSR Gosplan, only local optimization calculations have been realized, basically involving the siting of facilities of the production and nonproduction spheres, reallocation of various resources on the regional level, and improvement in the production structure within the sector. One of the reasons for this situation is the unstudied nature of the problems of determining the area of application of optimization models for planning the economic and social development.

It follows from the preceding that the development of the second phase of the ASPR of the Lithuanian SSR Gosplan has basically achieved an individual integration of the processing of plan information, created the groundwork for a change to "internally" proportionate, multiple-alternative planning calculations, and initiated a local optimization of planning decisions. Integration of the processing of plan information on a foundation of collective-use hardware and information resources, completion of the "internal" and realization of an "external" proportionality of multiple-alternative planning calculations, and creation of a system of integrated optimization of planning decisions are, in our opinion, the primary development trends for the ASPR of the Lithuanian SSR Gosplan in the 12th Five Year Period and the term up to the year 2000. This is essential for a unified automated technology of planning the social development of the Union republic.

In considering the creation of a unified automated technology of national planning as the primary long-term development goal of the ASPR, it is necessary to improve on certain principles and methods of development projects which have become the practice in this field. Most importantly, there should be a change from the individual-task to the integrated automation of planning, where an important part will be played by upgrading the structure of the functional section of the republic-level ASPR as a unified system.

The structure of the functional section of the ASPR of the Lithuanian SSR Gosplan has taken shape in accordance with the structure of the national plan and the organizational structure of the planning agencies, thus preordaining the existence of a large number of general and sector subsystems. Localization of the functional subsystems has held back (in our view) the assembling of planning calculations into complexes. Mutual coordination of the tasks of the functional subsystems by creating a central complex, a unified planning system for capital construction, and other such projects, essentially results in development of additional subsystems, virtually superimposed on the previously existing. To develop the ASPR of the Lithuanian SSR Gosplan in the direction of creating a unified automated planning technology, it is necessary (in our opinion) to consolidate the functional subsystems, using the divisions of the national plan as the criterion for their definition.

Analysis reveals that the tasks characteristic of the different modalities and stages of planning are far from equally represented in the functional subsystems of the second phase of the ASPR: in certain subsystems, the tasks of validation of the yearly draft plan are better developed, in others the calculations for the draft of the basic outlines of the five year period, in still others the tasks of supervising the implementation of the plan, and so on. This makes it impossible to run the full complex of calculations in the computer at each stage of preparation of the current and future plans, or to produce a full set of the corresponding planning documents in the computer.

In view of the above, it appears justified to adopt hereafter a so-called matrix functional structure of ASPR (cf. table). In this case, there are two types of functional subsystem: basic (modalities and stages of planning) and objective (divisions of the national plan). The objective subsystem provides for the development of a section (or several sections) of the national plan in all planning modalities and stages; the basic subsystem assures agreement and mutual correlation of all divisions of the national plan with respect to the individual planning modalities and stages. The end goal of the functioning of the basic subsystem is the computerized production of a full array of planning documents for an individual stage of a corresponding planning mode.

Until recently, the functional (economical planning) task has been the chief object of design and the primary unit of accounting in the ASPR. This was justifiable, given the batch mode of data processing and the easily manageable (because of their small number) range of tasks. Today, the interactive mode is becoming paramount and the emphasis is placed on creation and introduction of a unified automated planning technology. Therefore, the primary functional units should be consolidated to the maximum. In such capacity, we may adopt a composite functional complex without further subdivision into tasks.

Such ASPR complex is designed for multiple-alternative calculations of a given set of planning indexes. There is provided a broad assortment of procedures for processing the data collections and making computations by different methods and models. The complex can operate in different scenarios, specified by the user in interactive mode and differing from each other according to the array of procedures and their sequence. The complex will allow working off-line and interaction with other functional complexes. Each

Matrix Functional Structure of ASPR for Republics
with No Regional Division

Basic Functional Subsystems	Objective Functional Subsystems: General National Plan	Social Development and Increasing Standard of Living	Territorial Planning	Development of Science and Technology	Labor and Staffing	Net Costs and Profit	Environmental Protection	Logistics	Industry	Agroindustrial Complex	Capital Construction	Transportation and Communications
Initial specifications of the yearly plan												
Draft of the yearly plan												
Yearly plan												
Implementation of yearly plan												
Initial specifications of five year plan						Functional Complexes						
Draft of five year plan												
Five year plan												
Implementation of five year plan												
Long-term forecasting and planning												
Integrated target programs												

complex should be flexible, capable of supplementation and updating. Therefore, it should have a modular structure. Consolidation of such complexes where rational should considerably facilitate their mutual coordination into a unified technology of automated planning.

In developing the ASPR, integrated automation of the work of the Gosplan departments should be brought about, since these are the basic units where the planning process unfolds. In the present structure of the ASPR, the Gosplan departments are not conceived as integrated, but only work with individual tasks of the functional subsystems. The use of microcomputers and video terminals of general-purpose computers directly within the Gosplan departments is creating the technical possibilities for an integrated approach to the automation of their operation. The starting point should be a change to computerized organization of all information gathered and arriving at the departments, whereas today there is computerized management of information only for the tasks that are solved with use of computer. There should also be a transition to interchange of information between Gosplan departments, not only by means of unified documents, but also on computer storage media. All of this requires development and copying of a typical integrated system for data processing of a Gosplan department.

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CSO: 1863/39

CONCERNING SEVERAL ORGANIZATIONAL ASPECTS OF THE DEVELOPMENT OF THE PLANNING TECHNOLOGY IN A UNION REPUBLIC

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 22 No 5, Sept-Oct 86, pp. 864-870

[Article by E. Ya. Sture]

[Text] The 27th CPSU Congress has defined ways to improve the economic planning and the entire mechanism of management on behalf of faster socio-economic development. Realization of the corresponding measures requires active utilization of the achievements of scientific-technical progress in the planning activity. The process of their adoption in routine planning should be uninterrupted, controlled through a system of plans, and implemented by means of new organizational forms. In this process, the most diverse problems must be resolved: from rationalization of the structures, functions and organization of interaction of the various management agencies and utilization of economic-mathematical methods of optimization of planning decisions to the automation of planning calculations in distributed information computer systems.

It is well known that an isolated treatment of each such problem does not provide a sizable overall result. Therefore, the need arises for means and methods to regulate the process of implementation of the achievements of the theory of planning and economic cybernetics in routine planning activity. The array of such means and methods comprises a planning technology, the purpose of which is to achieve a consistency and mutual coordination, on a modern scientific-technical footing, of the structures and functions of the system of planning agencies, the methods of validation and implementation of planning decisions, the information flow and the time parameters of operation of the system, and its linkages to outlying systems [1].

It is often asked whether a planning technology is necessary, and whether strict regimentation doesn't complicate the practical activities of the planning offices. A streamlined technology in no way hampers initiative, but organizes the planning process, encourages its systematization, soundness and consistency of the decisions made, and provides the possibility of definite answers to the questions of who, what, how and when. All of this strengthens the purposeful nature of the planning activities, making possible an elimination of unnecessary elements, functions and tasks from the system and a fusion of planning theory and practice on the foundation of the achievements of scientific-technical progress.

This is perfectly analogous to the requirements for strict observance of the quality assurance technology of manufactured products. But while technology is a mandatory component in production processes, it is studiously avoided in planning processes under various pretexts.

In the modern setting, the importance of a technology of preparation and making of planning decisions is enhanced, especially in connection with the heightened demands of the CPSU Central Committee for their effectiveness.

Just as strict observance of the technology in material production assures an established quality of manufactured products, in the realm of management the formation and implementation of a sound technology of validation and making of decisions assures a high effectiveness of same. However, while production is simply inconceivable without a well-organized technology, the presence of such technology for planning is by no means recognized as essential by all. Meanwhile, in the modern setting, along with the growth in scale and complexity of the economic structure and the intensified interplay of social, production and scientific-technical factors, the role and importance of a scientifically valid planning technology are greatly increased. The correct determination of the planning problems, alternative solutions, and criteria of choice among these, the inclusion of limits on resources, the various factors, and the direct or eventual consequences, and ultimately the actual moment (time) of decision making govern the end result.

The technological aspect of planning has appeared most prominent in the process of design and adoption of the automated control systems of planning calculations (ASPR) in the USSR Gosplan and the gosplans of the Union republics.

The range of decisions made within the operation of the ASPR is characterized by two features. First, the decisions are very numerous and cannot be made by the same parties at the same time. Therefore, the process is divided into stages, during the course of which decisions are made by a single party, a group or groups of parties, or by a combination of these methods. The second feature is the impossibility of dividing the array of decisions into a number of independent sets. This means that the decisions made during the previous stages must be consulted during the following stages.

On the basis of the Leninist principles of planning and management, foremost the principle of democratic centralism, it is necessary to divide the functional goals of the automated control system of a republic (RASU) into levels during the design of the planning technology. The goals of a lower level appear in the capacity of the means of achieving the goals of a higher level. This enables a decomposition by the method of a goal tree in the formation of the system of goals of the ASPR of the republic gosplan and the ASU interacting with it.

In the modern setting, the main emphasis in management in general and in an ASU in particular is shifted from local regulating measures to integrated planning with clearly defined economic outlook. This is due to the objective need for a high-priority solution of the major problems of the economy, the increased importance of a more integrated justification and greater effectiveness of planning decisions, and the importance of cutting management expenses and making rational use of expensive computer hardware.

The national economy of a republic is an integral multilevel system with intricate structure, including the intersector, the sector, and the territorial components. It should operate accordingly, for maximum satisfaction of the requirements of the economy and the people for products and services by accelerating the scientific-technical and social progress and increasing the effectiveness of social production. The coupling of sector and territory management should provide consistency between the particular planning assignments and the general development goals of the republic economy, formation of the program, territory and sector aspects of the plan and their affiliation, and supervision of the implementation of the integrated development plans of the republic and of the target programs.

In creating the ASPR and the various ASU in a republic, the administrative principles and bureaucratic hierarchy should not stand in the way of introducing more effective forms of management, requiring the creation of unified information files and an integrated functioning of different systems in the solving of the problems of the economy. Thus, in particular, the problems of developing a rational ASU of a sector cannot be solved at present without taking into account intersector problems, particularly the future programs for organization of the interaction of different ASU in the territory of the republic [2].

In the Latvian SSR, a goal method was used to construct the functional management complexes (FKU) for capital construction, industry, the agroindustrial complex, public utilities, fuel and energy, and population during the process of development of the RASU. Such complexes are qualitatively novel forms of management, the distinguishing features of which are a multiple-sector orientation and technological interconnectedness. The FKU provide a rational coupling of sector, territory and target-program management.

In the FKU, the relationships objectively existing among the elements of the integrated management entity are identified and perfected. During this process, deficiencies of the existing scheme and management methods are found out and removed, such as, e.g., incomplete consistency between the criteria evaluating the activities of the sectors and the national economic interests, conflicts at the interfaces between sectors, and so forth. Therefore, in addition to creating ASU within the FKU, the assumptions regarding the particular ministries and offices are revised, as well as the economic indexes for evaluation of their performance and the methods of validating, coordinating and making planning decisions. In the final analysis, the operating effectiveness of the integrated management entity is upgraded, which comes about not so much by exploiting the software interface among its components, as by organizational-procedural measures promoting an improved interaction among the economic units comprising the entity.

Organization of the FKU requires an appropriate management system for this process. In the Latvian SSR, this is provided by development and implementation of an integrated program for creation of the RASU, the centerpiece of which is the ASPR of the republic Gosplan. The program specifies the interaction of the bureaucracy, sector and territory ASU in such critical areas as the future development of the sectors, technical-economic planning, management of scientific-technical progress, capital construction, labor resources, logistics, finances and monetary assets, as well as the formation of a system of norms and standards.

The creation of the individual FKU emerges as the subprograms of the aforementioned republic program, the management of which is done by the project directors nominated by the Council of Ministers of the republic. The project directors carry out the functions invested in them with the help of the executive organizations. The design chiefs of the FKU are directly subordinate to the project directors. The project directors are charged with the following responsibilities:

organization of the development of the subprogram for creation of the FKU with clearcut delineation of goals and fiscal justification of the outlay of resources and the economic effectiveness;

coordination and supervision of the measures and projects carried out in the ASU of the ministries and offices and essential to the FKU;

preparation of the subject of providing the required resources to the subprogram for creation of the FKU for review by the Interdepartmental Council of the Latvian SSR on Utilization of Computer Technology in the Economy;

organization of a continual exchange of scientific-technical and other information concerning implementation of the program measures among the cooperating executives;

preparation of proposals on use of the mechanism of economic incentives and improvement of the criteria evaluating ministry and office performance to achieve the economic goals of the FKU.

In order to create the FKU, it is necessary to rearrange the management information base, taking into account the system requirements and the new opportunities revealed by scientific-technical progress. Powerful computer technology and its system software enable an integration of the task complexes and certain subsystems within the information systems of the individual ASU (internal system integration), as well as a formation of integrated information systems of several management offices with proper regard for the question of their compatibility. An important part in this process is played by the automated data banks (ABD).

Until recently, the computer was primarily used to solve independent problems, aimed at carrying out a particular management function. Under such an approach, the different subdivisions of the management apparatus independently organized the data processing. The appropriate documentation would be readied for computer implementation and the information files created. As a result, not only the need for information essential to coordinate the functioning of the individual specialized subdivisions of the particular management agency, but also information enabling an interaction of a number of management agencies would be ignored. Such situation would result in noncomparability of identical indexes in the subdivisions of the management agencies, because of the different methodologies and computation technologies [3]. Moreover, repeated duplication of data would occur in the information cycle, and the data composition, substance and structure would not be unified. Only the output data of each subdivision of the management agency and their presentation formats would be standardized.

The development of integrated data processing systems, functioning on the basis of the ABD, obviates these shortcomings. However, the modernization of existing information systems and conversion to ABD cannot, generally, be achieved by an evolutionary process, i.e., the gradual transfer of certain information service functions from the previous system to the new system. This means that the conversion to the ABD necessitates a significant volume of work in creation of a data base, the substance and informational organization of which are fundamentally different from the traditional files.

An integrated approach to the construction of a system of indexes should provide an orderly arrival at the ABD of the basic characteristics of the economic or social process being managed, the features of its development, and the results, while the system of indexes should provide informational integration and interaction of the structural subdivisions of the management apparatus. This presupposes a mutual coordination of the quantitative physical and value indexes, in accordance with the structure and substance of the management functions and the technology of their implementation [4], which requires a knowledge of the complicated interrelationships among economic phenomena both in the sector and the intersector aspects, and the economic and social consequences of a change in certain factors of production and economic activities. Therefore, for a successful implementation, the characteristic methods of the management mechanisms of functional complexes require an information base in the form of an ABD, which enables comparability and accessibility of data on individual economic phenomena for a qualified appraisal and utilization in justification of decisions. An ABD of functional complexes opens up the possibility of synthesizing information from particular data for a management system of higher level, e.g., the ASPR of the republic gosplan.

Experience reveals that the creation of an ABD must resolve, not only technical and technological questions, but also such as pertain to the fundamental matters of organization of management. Thus, an extremely common occurrence is the sending of excessively detailed (trivial) information to the upper management levels. Obviously, this is necessary when it is a case of wrongful replacement of lower levels by an upper one, encroachment on their authority, and ignoring of so progressive a means of supervision as the checking of results. In this case, the creation of an ABD does not simply come down to automation of the existing information linkages, but requires a reordering of the management system.

A still frequent occurrence is the desire to stow away information "just to be prepared." This comes from the fact that the corresponding management agencies and their individual employees bear absolutely no responsibility for the expenses of acquisition of information. For example, in the Latvian SSR, while drawing up registers of the industrial enterprises a number of the management agencies insisted on a significant enlargement of the composition of indexes originally proposed by the Central Statistics Authority of the republic. Now, when an ABD of the enterprise registers is available, around 20 percent of the assembled and maintained information of its composition is in use.

Experience also shows that, unless the information flows in the ABD correspond to the actual needs of the executives, they will not be systematically analyzed, their accuracy will decline, and the information system will ultimately become useless.

Thus, the goals of gathering and processing of information on the base of an ABD should be defined from the standpoint of functional effectiveness of the entire management system and its individual components. Only with established goals can valid solutions be found for the problems of composition and substance of the information, formation of the data flows, and determination of formats, methods, and time frame of data preparation and processing. The resulting information model should reflect the technology of validation and decision making in the management system.

In evaluating the anticipated reliability of information in an ABD, it should also be recognized that human behavior in organizational (active) systems is determined by a range of factors of moral, material, psychological and status nature, which occasionally results in deliberate distortion of information on the capabilities, requirements and goals of the organization, as well as lower working effectiveness in absence of sufficient stimuli for fulfillment of the scheduled work [5].

It appears that dependability of information in the creation of major dynamic information files (ABD) of technical-economic information can only be assured when the critical planning and management decisions are made on the basis of the information flowing into the ABD, maintaining strict discipline in the use of the ABD by all management agencies. The right to make decisions circumventing the data banks will either lead to disruption of already operational information systems or make it impossible to create such.

It is necessary to emphasize yet another condition of effective use of ABD. The managers (management agencies) of the various ranks should receive information only in such state of aggregation as corresponds to the nature and subject matter of the decisions within their competence. But both the methods of management and the subjects of centralization or decentralization of the decision making largely depend on the personal qualities of the managers. This circumstance must be considered when creating an ABD, which should be sufficiently flexible and allow an executive working with strategic data to obtain information on particular matters, if necessary. Such condition becomes especially important in connection with the expanded use of minicomputers in data processing systems and the creation of local information computing networks and distributed data processing systems, enabling the management agencies to operate with a paperless technology.

In designing the planning technologies with ABD, it is exceedingly important to determine how the decisions will be prepared: by formalized computer procedures, by a person, or in a man/computer system with interactive facilities. It is essential to understand that, whatever the method, the selection is made not only in accordance with the technological capabilities, but also taking account of the training of the plan developers and psychological factors.

The development and adoption of modern automated planning technology creates the essential conditions for active practical use of optimization and other economic-mathematical methods, the capabilities of which are as yet far from fully exploited in the existing ASU of all levels.

The systems of data banks and computer interactive aids created in the republic during the 11th Five Year Period have enabled a development of optimization, econometric, balance and other models, and an active involvement of these in the practical planning technology. Out of a total of more than 1000 tasks, around 20 percent are being solved by economic-mathematical methods within the second phase of the ASPR of the Latvian SSR Gosplan, but it is these tasks which provide more than 80 percent of the overall economic impact of the second phase of the system.

The adoption of distributed information computing systems, minicomputers, and then personal computers as well, presents the management workers with the opportunity of independently designing and carrying out the information processing procedures. This opportunity is best realized by organizing automated work stations (ARM) for the planning and management employees. The ARM is a zone of applied managerial work (defined on the basis of the labor and other norms), equipped with hardware, software, and informational resources to allow an automation of the data processing and transmission, validation and making of managerial decisions, in accordance with the existing technology in the system.

The ARM can achieve a new quality level in the development of ASU, but only if a number of system requirements are necessarily observed. In fact, the presence of highly effective and automated information computing resources creates the danger of unauthorized use. The formation of individual information files using formalized data description facilities not compatible with those of the general system, violations of the requirements for validation of decisions, and other violations may sharply reduce or even cancel the effectiveness of automated planning and management technology. Hence the much greater importance and role, in the modern environment, of centralized control of the development of distributed data processing systems.

The decisions which most of all should be centralized are those implementing the system goals and requirements in the ASU. With a technology fashioned in this way, each employee retains the right to make a managerial decision, within his competency. However, the result of this decision should be represented by specifically organized information and entered into the system so that it can be used by other planning and managerial workers.

If the general system requirements are observed, the creation of distributed information computing systems with automated work stations can provide high effectiveness of contemporary managerial technologies. Calculations show that a single addressing of the data banks in the YeS computers from a display costs around 5.5 rubles, while access to a file previously prepared to suit the needs of the fellow employees in a minicomputer costs no more than 0.76 rubles, i.e., less than one-seventh.

It must be kept in view that acquisition of modern automated planning technologies is an extremely complicated and arduous process. It cannot be done in leaps and bounds. The introduction of new means and methods in the existing system of plan decision validation and making at a specific management office should be done by gradual reordering of its organizational structure, modifying the functions of the individual subdivisions, retraining and advancing the qualifications of the staff. However, the development and adoption of these technologies is not a passing fad, but a necessary condition for bringing the existing management systems into line with the current objects of management and the increasing demands for quality, efficiency, and effectiveness of management.

The experience of creating automated planning and management technologies in Latvia testifies that the complicated problems arising in this process are best and most painlessly solved if the ASU developers work from the very outset in close contact with the future users of the means and methods being designed, taking into account the reasonable desires and requirements of the planning and management practitioners and bearing responsibility for the proposed design strategies. In turn, the workers of the management apparatus should maintain an attentive and constructive attitude to the recommendations of the ASU developers and bear responsibility for proper formulation of the start-up tasks and for qualified use of the means and methods created in accordance with the adopted design strategies [6].

The overall level of development of the ASPR of the republic's Gosplan and of the RASU of Latvia, achieved in the 11th Five Year Period, and analysis of the accumulated experience and the scientific potential, suggest that the primary and chief task of 1986-1990 should be the integrated automation of the planning technology. This will promote a successful realization of the basic lines of improvement of the economic mechanism, worked out by the 27th CPSU Congress.

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CONCERNING THE APPLICATIONS OF FLEXIBLE MAN-MACHINE PLANNING DECISION-MAKING SYSTEMS IN THE CONTEXT OF AN AUTOMATED CONTROL SYSTEM FOR PLANNING CALCULATIONS

Moscow EKONOMIKA I MATEMATICHESKIYE METODY in Russian Vol 22 No 5, Sep-Oct 86, pp. 916-922

[Article by S. V. Chepel]

[Text] Economic-mathematical methods and computer technology are finding increasingly broad application in the practice of economic planning, chiefly as a tool of practical computations in drafting the national plans of economic and social development. Thus, within the first phase of the automated control system of planning calculations (ASPR) of the USSR Gosplan and the ASPR of the gosplans of the Union republics, brought into operation in 1977, more than 3300 economic planning problems were solved, while at present their number has grown to 11,000 [1]. As a result, the portion of planning documents produced directly from the computer or compiled on the basis of computer mathematical data has substantially increased, the quality of the plan is enhanced, and the development period is shortened. At the same time, the rate of adoption of the apparatus of economic mathematical modeling in practical economic planning and the degree of actual utilization of computers in the planning process are below the potential.

Given the considerable success in creation of the individual models and their systems as used for scientific purposes, the achievements in the construction of models which are actually being used in the development of plans and are capable of being incorporated into the technology of the planning process are beyond modest. This is due to a number of factors. Thus, the models designed primarily for scientific purposes are "geared" to solve, as a rule, a single problem, consist exclusively of formalized procedures, and take little account of the realistic possibilities of the software of planning computations.

However, the nature of five year and long term pre-plan computations makes it necessary to employ economic mathematical models primarily in conditions of consultation between the planning analysts and the computer, in order to determine the probable consequences of certain planning decisions and choose the better of them. What is needed here is not only an informed sorting through the values of certain original controlling parameters and indexes, but also a change in the composition and structure of the input and output information, the computational algorithm, and the form of the optimization criteria and constraints.

All this has played a stimulating role in the development of methods of simulation modeling [2], elaboration of the apparatus of multiple-criterion mathematical programming problems [3], and extensive use of computer technology for planning computations, oriented toward interactive mode [4].

The result of this is the creation of flexible (adaptive) man-computer planning systems. The development of these should employ such facilities and methods of organization of the information processing and solving of economic planning problems as can be easily adapted to a change in the socioeconomic conditions, policy guidelines, logic and technology of development of plans, and changes in the organizational structure of the planning agencies.

The adoption of man-computer procedures in planning should render the data banks stable to various kinds of structural changes in the ASPR and bring about universal (flexible) formulations of the economic planning problems, enabling rather free variation of the compositions of input and output variables, constraints, and optimization criteria.

The chief merit of such systems is the fact that they can solve a broad spectrum of economic planning problems of the given category of ASPR with a minimal volume of reference and planning information.

The plan decisions made on the basis of man-computer procedures also have a higher degree of reliability, since the process of verification of their indexes makes extensive use not only of highly effective methods and models, but also expert appraisals of the Gosplan specialists, which makes it possible to consider the influence (to some extent) of nonformalizable factors as well. All this is responsible for the development and adoption of flexible multipurpose interactive systems of plan decision making as one of the crucial trends in future ASPR development.

At the same time, the practical implementation of this trend involves a number of well-known difficulties, deriving not only from the considerable complexity of the investigated object itself, but also the insufficient scientific work done in the field of creating the foundation for design of man-computer plan decision-making procedures.

From an analysis of the work done in this field, we may conclude that one of the most promising approaches in the solving of this problem is the algorithmic method, which is being actively pursued at the UzNPO Kibernetika of the Uzbek SSR Academy of Sciences [5]. Its essence consists in the fact that the concept of a model is replaced by a list of formalized procedures which, together with a separate set of nonformalized operations, constitutes the functional structure of the problem complex.

The interrelationship between each specific task of the complex and the volume of its input and output indexes, as well as its interrelationship with the list of formalized procedures used in its solution, is determined by a functional table. In turn, the data of this table form the foundation of the procedure for "tuning" the multipurpose interactive system to the solving of a specific planning problem, to be conducted by the user in computer interactive dialogue.

Let us consider an example of the use of the algorithmic method in designing a flexible multipurpose problem complex for verification of aggregate indexes of balance of the national economy of a Union republic over the long term future. Such complex is being developed within the "General Economic Plan" subsystem of the ASPR of the Uzbek SSR Gosplan. Its first version has been used in validating the general development indexes of the republic in the stage of pre-plan long term computations.

The point of departure in the design of any given ASPR plan complex is the formulation of its functional structure, to be determined by the indexes of that section of the plan which the complex is designed to analyze. The results obtained during this stage are used in developing the elements of the functional table, formulating the composition of the input and output information, and processing the basic language structures of the computer dialogue.

The multipurpose complex of economic planning problems, to be described here, is intended to forecast and verify the aggregate balance indexes of the economy of a republic. Therefore, the input and output information of the complex have the following structure:

a) volumetric indexes, computed over the territory of the republic as a whole and including the aggregate social product X^t, the mean annual net cost of the primary production assets F^t and the number of workers occupied in the production sphere L^t;

b) the same indexes x_i^t, f_i^t, l_i^t, determined on the cross section of four sectors of the economy (industry, construction, agriculture, other sectors);

c) characteristics of the sector structure (in fractions) of the gross production $\bar{x}^t$, primary production assets $\bar{f}^t$, number of workers occupied in material production:

$$\bar{l}^t\left(\sum_i \bar{x}_i^t=1,\ \sum_i \bar{f}_i^t=1,\ \sum_i \bar{l}_i^t=1\right);$$

d) indexes for the effectiveness of utilization of labor resources and primary assets--the labor productivity α_i^t and the capital productivity β_i^t.

It is important to observe that any of the above indexes, depending on the goals and the problems of the controlled computer experiment, may operate as an exogenic or nominal index, be an optimization variable or a control parameter, an optimization criterion or a constraint.

The list of formalized procedures of the problem complex for validation of aggregate balance indexes includes the following relations (Footnote *) (To simplify the presentation of the principles of design of flexible multipurpose systems for validation of planning indexes, the list of formalized procedures is also given here in a simplified form. In particular, it does not include the equations of the investment section, nor the balance relations for the formation and allocation of the national income):

$$x_i^t = \alpha_i^t l_i^t,\ l_i^t = \bar{l}_i^t L^t, \tag{1}$$

$$x_i^t = \beta_i^t f_i^t,\ f_i^t = \bar{f}_i^t F^t, \tag{2}$$

$$\alpha_i^t = a_i (f_i^t / l_i^t)^{b_i} l^{c_i t}, \tag{3}$$

$$f_i^t = [x_i^t / [a_i (l_i^t)^{1-b_i} l^{c_i t}]]^{1/b_i}, \tag{4}$$

$$l_i^t = [x_i^t / [a_i (f_i^t)^{b_i} l^{c_i t}]]^{1/(1-b_i)}, \tag{5}$$

$$\alpha_i^t = x_i^t / l_i^t, \tag{6}$$

$$\beta_i^t = x_i^t / f_i^t, \tag{7}$$

$$X^t(\bar{f}^t,\ l^t) \rightarrow \max, \tag{8}$$

$$L^t(\bar{l}^t,\ X^t) \rightarrow \min, \tag{9}$$

$$F^t(\bar{f}^t,\ X^t) \rightarrow \min, \tag{10}$$

$$\bar{f}_i^t \in [\bar{f}^t_{i\,\min}, \bar{f}^t_{i\,\max}],\ \bar{l}_i^t \in [\bar{l}^t_{i\,\min},\ \bar{l}^t_{i\,\max}], \tag{11}$$

$$\bar{f}^t_{i\nu} = \bar{f}^t_{i\nu-1} + s_\nu \nabla X^t (\bar{f}^t_{\nu-1}) / \| \nabla X^t (\bar{f}^t_{\nu-1}) \|, \tag{12}$$

$$s_\nu = p \min_i \{ |\bar{f}^t_{i\nu-1} - \bar{f}_{i\,\min}|,\ |\bar{l}^t_{i\,\max} - \bar{l}^t_{i\nu-1}| \}, \tag{13}$$

where $\bar{f}^t_{i\,\min}, \bar{f}^t_{i\,\max}, \bar{l}^t_{i\,\min}, \bar{l}^t_{i\,\max}$

are the minimum and maximum allowable values of the structural indexes of the production resources used (assets and labor), specified by the user of the system; $\nabla X^t(\bar{f}^t_{\nu-1})$ is the gradient of the function X^t (calculated on the basis of procedures (3), (1)) with respect to the vector variable $\bar{f}^t$ at point $\bar{f}^t_{\nu-1}$; ν is the number of the iteration of the procedure to find the approximate solution; $\bar{f}^t_{opt}$ is the best (from the standpoint of criterion (8)) sector structure of the primary production assets; p is a parameter determining, on the one hand, the speed of convergence of the iteration procedure (12), (13), and on the other, the accuracy of the obtained solution $\bar{f}_{opt}$.

The list of formalized procedures of this problem complex carries out both direct planning computations (relations (1), (2), (6), (7)) and calculations based on the methods of mathematical statistics (regression equations (3)-(5)) and optimal planning (criteria of optimality (8), (9), (10), constraints (11), procedures to find an approximate optimal solution (12), (13)). While the majority of these relations have a perfectly clear economic meaning, certain explanations are required for (3)-(5), as well as (12), (13).

The first of these lets us determine the level of labor productivity α_i^t in the sectors of the economy. It is based on procedures developed by the NIEI of the USSR Gosplan [6], according to which the level of labor productivity is defined by its capital-labor ratio f_i^t/l_i^t and is a function of the time t.

The advantage of such approach, as opposed to the traditional one based on use of the Cobb-Douglas production function, is a much greater stability of the statistical parameters a_i, b_i, c_i of the production function (3), as well as the possibility of distributing the growth of product between extensive and intensive components.

The excellent statistical properties of the production function (3) are illustrated by the data of Table 1, obtained from the results of a processing of dynamic series of indexes of labor productivity and capital-labor ratio in the national economy of the republic for 1977-1983. It follows, in particular, from these that the mean deviation of the estimate of gross production from the actual value for the republican economy as a whole during this term did not exceed 1 percent.

Table 1. Values of Deviation of Reported Indexes of Gross Production from the Estimates Obtained by (3), Percent

Accounting Year	Industry	Construction	Agriculture	Other Sectors	Entire Economy
1977	−0,04	−1,38	−0,3	0,12	−0,28
1978	0,93	0,54	3,35	0,13	0,25
1979	1,75	0,24	3,95	0,92	−0,41
1980	0,45	2,06	2,61	−0,93	−1,24
1981	1,15	2,04	−1,49	0,0	0,87
1982	−0,54	−2,52	−2,33	−0,21	−0,83
1983	−0,87	−5,10	−0,69	0,43	−1,55
Mean deviation of estimate from actual (by modulus)	0,79 0,98 2,68	2,18 0,51 1,97	1,99 0,61 2,03	0,42 1,0 2,96	0,82 – –

The regression equations (4), (5) are obtained from (1)-(3) and used to compute the volumes of production resources for set rates of growth of gross product.

Finally, (12) and (13) implement the gradient method of solving the nonlinear problem of maximization of the total social product (8) (the problems of minimization of the production resources (9), (10)) with respect to the variable $\overline{f}^t$, subject to constraints (11) on changes in the sector structure of primary assets $\overline{f}_{i\ min}$, $\overline{f}_{i\ max}$, specified by experts. The scheme for finding a sector structure of workers occupied in the sphere of material production $\overline{l}^t_{opt}$ that is optimal from the standpoint of criterion (8)-(10) is similar to algorithm (12), (13).

All the formalized procedures of the problem complex for prediction and verification of balance indexes of the economy of a republic have been run in the minicomputer Iskra-226 and are quite technologically effective in operation.

The experience in using the complex to validate the primary parameters of development of the republic for the 12th Five Year Period and the term up to the year 2000 revealed that the average time to formulate a single alternative, including 24 output indexes, is 1-2 min in direct planning computations, 3-5 min when using the regression equations, and 7-8 min in optimization of the sector structure of resources.

An important place in the design of flexible economic planning problem complexes of ASPR is given to the formulation of the functional table, which includes the vital information on each problem contained in the complex.

The composition and structure of problems unified into complexes and described in a functional table depend on the requirements imposed on the automation of computations of the particular segments of the draft plan (Table 2).

Verification of alternatives of development of the republic's economy on the level of the aggregated balance indexes of its economy primarily involves solving problems which allow an estimation of the rates of growth in the scale of the social production for given resource volumes (labor and primary production assets).

As follows from Table 2, the input for these (problems (1)-(3)) are the resource volumes and one of the indexes of effectiveness of their utilization, while the output is the indexes of gross production and the other index of effectiveness. Each input index may behave as a control parameter, which substantially enlarges the possibilities of fitting the complex into the current planning technology.

Thus, if a given level of labor productivity (capital productivity) is to be established for the future term by the expert, it is necessary to turn to problem (1), (2), in which the control parameters are the indexes $\alpha^t(\beta^t)$. But if it is necessary to evaluate the influence of changes in the sector structure of resources on the rates of development of the social production and its effectiveness, the computation alternatives will be based on the formalized procedures (1), (3), (7) with different values of control parameters $\overline{f}^t$, $\overline{l}^t$.

The second group (problems (4), (5)), in a certain sense, is the opposite of the first three. These are used to compute such resource volumes as assure given rates of growth of gross production. The input of these problems is the indexes of volumes of gross production and one of the two production resources used in the computations, while the output is the minimum necessary volumes of the other resource, as well as the indexes of effectiveness of social production.

In addition to the described forecasting problems, the complex can also implement a number of optimization planning computations (problems (6)-(8))

Table 2. Functioning of a Multipurpose Problem Complex for Validation of Aggregate Balance Indexes of a Republic's Economy in the Long Term

Problem	Specified Indexes (Input)									Indexes to be Computed (Output)							Numbers of Formalized Procedures (Computational Algorithm)
	X^t	F^t	L^t	$\bar{f}^t$	$\bar{l}^t$	α^t	β^t	$\bar{f}^t_{\min\max}$	$\bar{l}^t_{\min\max}$	X^t	F^t	L^t	$\bar{f}^t_{opt}$	$\bar{l}^t_{opt}$	α^t	β^t	
1		×	×	×	×		×			×					×		2, 6
2		×	×	×	×	×				×						×	1, 7
3		×	×	×	×					×					×	×	3, 1, 7
4	×		×	×	×						×				×	×	4, 6, 7
5	×	×		×	×							×			×	×	5, 6, 7
6	×		×		×			×			×		×		×	×	10, 11, 12, 13 4, 6, 7
7	×	×		×					×			×		×	×	×	9, 11, 12, 13 5, 6, 7
		×	×					×	×	×			×	×	×	×	8, 11, 12, 13 3, 1, 7

on the basis of the identical information, involving the validation of the most rational changes in the structure of resources.

The solution is such structural indexes $\bar{f}^t_{opt}, \bar{1}^t_{opt}$, determined over the entire planning interval, as satisfy the constraints (11) and minimize the overall volumes of expenditure of one of the production resources for given rates of growth of gross production (problems (6),(7)) or maximize the volume of gross social product in a setting of declared limits on resources (8).

Thus, with the identical set of indexes, the complex discussed here is able to solve a broad spectrum of economic planning problems of forecasting and verification of summarized indexes of economic development of a republic. The speciality of the complex is the fact that transition from one problem to another does not involve a rearrangement of its structure, nor extensive modification of the software. This greatly enhances the practical importance of such systems.

Yet another merit of the algorithmic approach in design of flexible man-computer plan decision-making systems is the fact that the calculation results obtained by solving certain problems of such systems and complexes can be used as the input information in other problems. For example, the rates of growth of gross production, found by solving problem (3), are the initial data (cf. Table 2) in verifying the optimal changes in the sector structure of resources. In turn, the optimal estimates $\bar{1}^t_{opt}, \bar{f}^t_{opt}$ can be used as control parameters (4), and so on.

Consequently, by means of an informed progression from the solution of one problem to another, the system user (expert, Gosplan specialist) in a controlled computer experiment has the opportunity to formulate and verify the most effective alternatives for reaching the primary goals of development of the republic's economy. Furthermore, the role of the Gosplan specialists in the process of carrying out the calculation alternatives also consists in implementation of nonformalizable operations, associated with the formation of the initial preconditions and hypotheses of change in the control parameters of the problem, analysis of the obtained results, selection of directions of future analysis, and so forth.

Among the problems not represented in the present work are, foremost, the principles of design of technological schemes for planning calculations based on formalized and nonformalized operations. Also deserving of thorough scientific development are the subjects of problem-oriented man-computer interactive languages which take into account the specifics of the technology of planning and investigation of convergence of iteration procedures of planning calculations, and principles of construction of data bases that are invariant with respect to various kinds of structural changes in the ASPR.

As shown by the results of scientific studies and the experience of developing ASPR in the USSR Gosplan and the gosplans of the Union republics, the solving of these problems will be the primary trend in the future development of the ASPR, which is an important component in the overall complex of measures for upgrading of the planning process.

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CSO: 1863/39

CALCULATION OF VOLUMES OF INFORMATION-COMPUTATIONAL WORK IN THE INDUSTRIAL MANAGEMENT SYSTEM OF THE REPUBLIC

Yerevan PROMYSHLENNOST ARMENII in Russian, No 7, Jul 86, pp 58-50

[Article by G. G. Oganesyan, engineer]

[Abstract] A new approach has been developed for calculating the volume of information-computational work required to perform a task, considering both the time requirements set forth in the standard handbooks and the peculiarities related to the general concept of the inter-branch management complex. The volume of information stored in the automated data base is determined in this method by direct computation based on data from the inter-branch administrative complex, using annual adjustment figures. The sequence of computation of the volume of information-computational work is noted. The method is suitable for determination of the workload generated by actual regional computer center network subscribers. References 1: Russian.

6508/12955
CSO: 1863/103

ORGANIZATION OF AUTOMATED INFORMATION PROCESSING IN USSR CONSTRUCTION BANK ESTABLISHMENTS

Moscow FINANSY SSSR in Russian, No 10, Oct 86, pp 54-59

[Article by A. F. Litvinenko, candidate of economic sciences]

[Abstract] Over half of the USSR construction bank establishments presently process accounting information by computers, utilizing large Stroybank or other computer centers. Although large computer centers have definite advantages, including lowest cost and best centralized management of computer resources, they also have definite disadvantages. While centralized computer centers were appropriate for previous stages in the development of computer technology, a more appropriate approach for today might be the use of microcomputers and electronic calculators to decentralize much of the data processing now centralized at the large computer centers. The use of small computers for daily bank accounting on such machines as the "Neva-501" and "Iskra-226" is discussed. Decentralization reduces the time

required for information processing, eliminates the need for a courier and increases reliability of results. Direct data input can further improve efficiency by eliminating repunching of data and freeing up computer operators.

6508/12955
CSO: 1863/105

SOURCES OF ECONOMIC EFFECTIVENESS OF INTRODUCTION OF AUTOMATED MANAGEMENT SYSTEMS

Moscow FINANSY SSSR in Russian, No 10, Oct 86, pp 59-61

[Article by A. M. Kizhner, "Sibtsvetmetavtomatika" Scientific-Production Association]

[Abstract] Profit is used as the criterion for evaluating the effectiveness of systems. Introduction of automated management systems can increase profit by decreasing administrative wages, increasing production, accelerating goods turnover, minimizing penalties for failure to meet contractual obligations, decreasing equipment downtime costs, and minimizing costs of debt servicing. Automated marketing and production management systems have been introduced at a number of USSR concerns, but analysis has shown that the actual economic effectiveness of these systems is very low, since in most enterprises they are used only for accounting and computation intended to reduce labor consumption in accounting operations. Computations further show that even if an automated management system could eliminate the jobs of all administrative workers, the system would still not save money, due to the very high cost of the computers required. Unless automated management systems truly improve marketing and increase production, they cannot, therefore, pay for themselves by administrative cost savings alone.

6508/12955
CSO: 1863/105

UDC 658.012.011.56

TRENDS IN THE APPLICATION OF COMPUTERS FOR VARIOUS ADMINISTRATIVE FUNCTIONS IN LITHUANIAN INDUSTRY

Vilnius TRUDY AKADEMII NAUK LITVOSKOY SSR: SERIYA A in Russian, No 3, 1986 (manuscript received 2 Aug 85) pp 3-12

[Article by Yu. M. Birbilene, B. Yu. Blazhis and V. K. Kyaras, Institute of Economics, Lithuanian Academy of Sciences]

[Abstract] A study is presented of the economic and organizational aspects of the practice of using electronic computers to perform various administrative functions at industrial enterprises in the Lithuanian SSR, to determine

and estimate contemporary trends and their future development. The application of computers to administration is divided into three great stages: In Stage 1, computers were used to perform individual calculations; in Stage 2, computers are used to make the flow of information more efficient, standardize documents and make broader use of the results of automated calculations in management; in Stage 3, administrative functions are completely automated, and man simply follows the course of the production process and writes programs to regulate it. The utilization of computer equipment in each stage is described. It is concluded that computers and automated management systems have become a component part of the practice of administration of industrial production. At present, it is primarily accounting which is automated, though this yields the minimum economic effect. Automated management systems are presently expanding primarily in breadth, increasing the total number of tasks performed, rather than in depth, in the direction of complete performance of planning, prediction and operational management. The authors call for coordinated development of automated management systems, with economic demonstration of the effectiveness of proposed projects, systematic and complete automation of administrative functions. Insufficient attention as yet is given to the role of people and the new capabilities which automation of management functions gives to people. It is important, in the earliest planning stage, to give deeper attention to the actual processes of administration in terms of planning, accounting and regulation when designing automated management systems. References 5: Russian.

6508/12955
CSO: 1863/101

MECHANIZATION OF ACCOUNTING FOR LABOR AND WAGES WITH MICROCOMPUTERS

Moscow BUKHGALTERSKIY UCHET in Russian No 5, May 86 pp 38-39

[Article by Ye. V. Keda, Chief, Computer Center, Construction Trust Number 29, BSSR Ministry of Industrial Construction]

[Abstract] "Promstroysistema" Production-Technical Association of the Belorussian Industrial Construction Ministry has developed a program system to automate a bookkeeper's work station using an Iskra-555 microcomputer. The program automates accounting for labor and wages in the central office of Construction Trust Number 29. This process has proven to be less costly than performing the same work on a YeS-1022 computer. Work is also performed in a more timely manner and the reliability and quality of the information processes have been improved.

6508/12955
CSO: 1863/31

MACHINE PROCESSING OF AUDIT INFORMATION

Moscow BUKHGALTERSKIY UCHET in Russian No 5, May 86 pp 11-13

[Article by G. A. Solovyev, Department Chief, Irkutsk Institute of the Economy and V. I. Lakis, Docent, Vilnyus State University imeni V. Kapsukas]

[Abstract] Machine processing of audit information has been undertaken in the Auditing Administration of the Lithuanian Finance Ministry. The Auditing Administration of the RSFSR Finance Ministry for Irkutsk Oblast has begun experimental machine processing of audit information. This article presents a description of forms which are filled out for the purpose of automated auditing, and procedures for implementing machine audits. The procedure involves generation of cards indicating the results and effectiveness of auditing operations, the use of machine-readable information sources such as punch cards, the creation of constant and variable files of information, development of instructions for machine processing of audit information, the use of a standardized coding system, and transmission of audit information by teletype or by shipping of cards carrying the results and information on the effectiveness of auditing to superior auditing organizations. The information thus produced is timely and therefore more effective for administrative purposes.

6508/12955
CSO: 1863/31

AUTOMATION OF INTER-AFFILIATE FUNDS TRANSFER OPERATIONS

Moscow DENGI I KREDIT in Russian, No 7, 1986, pp 45-51

[Article by P. V. Dyatlov, Department Chief, State Bank Main Computer Center]

[Abstract] Transfers among Gosbank affiliates is an operation which is still performed manually in many places, utilizing the telegraph network. Gosbank uses a program of checking for errors in inter-affiliate transfers using 9 centers equipped with YeS machines, 19 centers equipped with M-5000 machines, and other centers using tabulators, sorters, and punch cards. Many mistakes arise in the punching process and due to the errors on the telegraph network. Automation of this process could save manual punching of over 150,000 punch cards per day, releasing some 100 operators. This article discusses in very general terms possible techniques for mechanization of this process, including networking of computers, production of magnetic tapes which are used to transfer information physically to regional computer centers, and eventual transfer of these operations from the regional computer centers to the main computer center over communications channels to allow a second stage of centralized processing of funds transfer data at the highest level. This fully automated processing of information will eliminate human intervention and possible error from the moment the initial

data are input into the computer through output of final results of processing.

6508/12955
CSO: 1863/61

UDC 681.327.6:621.9.06-529

AUTOMATED DATA BASE OF NUMERICALLY CONTROLLED MACHINE TOOLS

Moscow STANKI I INSTRUMENT in Russian, No 5, May 86, pp 7-11

[Article by O. I. Averyanov and Ya. M. Gelshteyn]

[Abstract] An automated data base has been developed containing information on both Soviet and foreign program-controlled machine tools. Based on the INES DBMS, the data base runs on the YeS series of computers. The hierarchical data base lists the technical characteristics of metal-cutting machine tools in a form convenient for automated retrieval and analysis. A sample coding form is presented. Figures 6, references 6: Russian.

6508/12955
CSO: 1863/61

UDC 62.83.526.001.57:658.011.56

AUTOMATED SUBSYSTEM FOR MODELING AND SYNTHESIS OF TRACKING ELECTRIC DRIVES

Moscow STANKI I INSTRUMENT in Russian No 5, May 86, pp 11-14

[Article by S. A. Avdushev, O. L. Volberg and Yu. G. Perchenok]

[Abstract] The Leningrad Experimental-Design Bureau for Machine Tools has developed an application software system for analysis and synthesis of electric drives with numerical control, so-called digital electric drives. The software is designed for detailed simulation of digital and analog electric drive systems for heavy machine tools. The models produced by the software take into consideration the specific peculiarities of the dynamics of dc valve electric drives resulting from the use of semiconductor converters. An important feature of the software is its representation of both discrete and continuous parts of the drives by the same finite-difference mathematical description. A system of parts and library of functional models are used by the software. The software runs on YeS machines using DOS and on SM-4s running RAFOS. Figures 3, references 9: Russian.

6508/12955
CSO: 1863/61

UDC 550.3+681.51/54

AUTOMATIC MINI-SYSTEM FOR RECORDING OF GEOPHYSICAL PHENOMENA

Tbilisi SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian, Vol 123, No 1, Jul 86 (manuscript received 13 Sep 85) pp 65-68

[Article by O. K. Shoniya, Institute of Geophysics, Georgian Academy of Sciences]

[Abstract] A previous article described a mini-system for recording of geophysical data, consisting of a standard strip chart recorder, analog-digital converter and paper tape punch. This article briefly describes the characteristics of the system, indicating that it can be used to record data from several sensors in a form convenient for later input to almost any computer. The maximum data rate is determined by the characteristics of the paper tape punch, and is up to 1 Kbits/sec (20-150 readings per second). The system is turned on and off automatically by the arrival of a signal from the geophysical sensor, which moves the needle of the strip chart recorder off zero, causing light to strike a photoelectric cell placed beneath the pin at the zero position. A sample recording of an earthquake event is presented. Figures 3, references: Russian.

6508/12955
CSO: 1863/61

UDC 681.32

ESTIMATION OF PARAMETERS IN FULLY OBSERVABLE NONLINEAR STOCHASTIC CONTROL SYSTEMS

Tbilisi SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian, Vol 128, No 2, Aug 86 (manuscript received 21 Sep 84) pp 365-368

[Article by V. V. Mdzinarishvili, Scientific Research Institute of Automation of Production Processes in Industry, Gori]

[Abstract] A previous work presented a general method for solving Fokker-Planck-Kolmogorov equations. This article, based on the concepts developed in the previous work, presents an effective algorithm for estimating parameters in closed nonlinear stochastic control systems. Solution of two linear algebraic equations derived in the article by known methods of search for an extreme allows estimation of the numerical values of the desired parameters. The results can be extended to the multivariate case. Reference 1.

6508/12955
CSO: 1863/67

UDC 681.513.5

COORDINATED CONTROL IN BINARY ACTIVE SYSTEMS

Tbilisi SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian, Vol 128, No 2, Aug 86 (manuscript received 15 Nov 85) pp 369-371

[Article by I. A. Gorgidzye]

[Abstract] The task of constructing the optimal mechanism of functioning in a binary active system is analyzed as a special form of vector optimization, a metagame of two centers. Information may be exchanged between the centers in the process of formation of data in the system. Assuming that the centers are fully informed concerning models of elements, the set of possible states, given selected mechanisms of interaction, each center can

predict the set of states corresponding to selection of elements with various hypotheses concerning their behavior. A theorem is produced concerning optimality of coordinated action mechanisms in such a binary system. References 3: Russian.

6508/12955
CSO: 1863/67

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